UNIVERSITY OF LONDON THESIS

Degree PhD Year 2007 Name of Author PEARCE, Mary Dorothy

The interaction of tone with voicing and foot structure:

Evidence from Kera phonetics and phonology

Mary Dorothy Pearce

Department of Phonetics and Linguistics
University College London

Thesis submitted to the University of London in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

2007

Abstract

This thesis uses acoustic measurements as a basis for the phonological analysis of the interaction of tone with voicing and foot structure in Kera (a Chadic language). In both tone spreading and vowel harmony, the iambic foot acts as a domain for spreading. Further evidence for the foot comes from measurements of duration, intensity and vowel quality. Kera is unusual in combining a tone system with a partially independent metrical system based on iambs. In words containing more than one foot, the foot is the tone bearing unit (TBU), but in shorter words, the TBU is the syllable.

In perception and production experiments, results show that Kera speakers, unlike English and French, use the fundamental frequency as the principle cue to "voicing" contrast. Voice onset time (VOT) has only a minor role. Historically, tones probably developed from voicing through a process of tonogenesis, but synchronically, the feature [voice] is no longer contrastive and VOT is used in an enhancing role. Some linguists have claimed that Kera is a key example for their controversial theory of long-distance voicing spread. But as [voice] is not part of Kera phonology, this thesis gives counter-evidence to the voice spreading claim.

An important finding from the experiments is that the phonological grammars are different between village women, men moving to town and town men. These differences are attributed to French contact. The interaction between Kera tone and voicing and contact with French have produced changes from a 2-way voicing contrast, through a 3-way tonal contrast, to a 2-way voicing contrast plus another contrast with short VOT. These diachronic and synchronic tone/voicing facts are analysed using laryngeal features and Optimality Theory.

This thesis provides a body of new data, detailed acoustic measurements, and an analysis incorporating current theoretical issues in phonology, which make it of interest to Africanists and theoreticians alike.

Acknowledgements

When I came to UCL to study for an MA in Phonology, I thought my stay would be for one year. The reason that one year became five and resulted in this thesis is due largely to the tremendous opportunity I had in having Moira Yip as my supervisor. In the words of Paul de Lacy, I would have been a fool to miss the opportunity. Moira's phonological expertise is well known, but beyond that, she has also been a brilliant teacher and supervisor. She has put up with excessive amounts of reading material from me which in early days she described as my 'streams of consciousness'. But she returned all my efforts to me within a couple of days, full of helpful comments. I am somewhat encouraged by reading the acknowledgements page of her PhD thesis which tells how her supervisor "patiently submitted to a weekly exposure of fresh torrents of unfamiliar and confusing data" and how he helped her gradually make sense of it all. I'm afraid I have caused her to know what that feels like from the other side of the relationship. But I am extremely grateful for her patient supervision, encouragement and belief in me, and I am glad to be able to count her as a good friend too.

Of course this thesis would not exist at all without the input of several Kera speakers. I do not have room to name all those that I worked with during my extended stay in Chad during 1992-2002 and my two field trips in 2004 and 2006. But some I must mention for the many hours they spent patiently saying what I wanted them to say several times over into a microphone. The Kera translation and literacy team were all a great help and encouragement including Aidjo Felix, Ouangmene Simon, Pamna Alexis, Bulwa Philippe, and Kouri Benjamen. Aidjo in particular has the skill of spotting interesting things about his language. He managed to find around sixty words containing the Kera labio-dental flap. He also spotted the fact that some word final [i] sounds were different from others and promptly named them "phantom [i]s". I'm grateful for the input of several other Kera including: Abraham Besba, Ainou Kassaobel Joseph, Asba Buksibel, Atchitouang Christophe, Baktouing Moïse, Bernard Nestor, Dayda Dumpiam, Dikwe Jean, Djibrine Justin, Gəəzi Frédéric, Haamaamo Gabriel, Ilyang Eli, Kolwe Mallam Ezekiel, Kotwe Jerome, Mamadou Larkamla, Mankreo Bernard, Markumna Elizabeth Kupora, Mayanla Mainsala Katherine, Mené Romanic, Nenbe Nestor, Wiwa Irene, and Yaŋkəm Tawsala Victor, and my thanks go to others who did perception tests for me (32 Kera, 19 English and 5 French speakers), and several Kera who allowed themselves to be recorded. Many of the Kera have become good friends, and I remain very grateful for their welcome as I lived among them and for the patient way they have coped with my mistakes – both in language skills and culturally.

During my time in Cameroon and Chad, I also appreciated the support and friendship of my SIL colleagues, particularly Jackie Hainaut who was my co-worker among the Kera. Several encouraged me to pursue my interest in linguistics, most noticeably Robert Hedinger, Keith Snider, Stephen Bird, Jim Roberts, and Ruth Lienhard. My thanks go to them for seeing a potential that I didn't see. Also thanks to Elaine Bombay, Lukas Neukom, John Symons, and Liz Williams for running perception and production tests for me and various linguists who have encouraged me in conferences and in correspondence, including Mike Cahill, Rod Casali, Laura Downing, Colin Ewen, Gunnar Hansson, Francis Katamba, Bill Labov, Bob Ladd, Peter Ladefoged, and Ken Olson to name but a few.

In UCL, I have thoroughly enjoyed my time in the Phonetics and Linguistics department. It must be one of the best places to do linguistic research with a friendly and extremely competent set of staff and a great bunch of people in the PhD room. I particularly appreciated the friendship of Gloria Malambe, Nina Topintzi, Jill House, Molly Bennett and Judith Crompton. John Harris, as my second supervisor, has been a great encouragement for Phonology and life in general. Eric Carlson has been a big help in advising me on IT matters and particularly in the use of PRAAT. Steve Nevard, Yi Xu and Chris Donlan have also given me help in technical areas of this research. I am also very grateful for the helpful comments, encouragement and enthusiasm of my examiners, Larry Hyman and Carlos Gussenhoven. They made my defence a pleasure.

Even with all of these people, I could not have begun to study without the encouragement and support of many friends and churches. They have provided the means for me to live in London and to study. Many of them started to support me while I was in Chad and I am grateful to them for their continued interest in me and my work during this time in London. They could easily have lost interest, but they didn't. Special thanks go to the Cole family, the Darrer family, Sarah Fidal and Grantham Baptist Church for their support and help, and to SIL International and SIL-Chad for providing some funds to help cover fees and conference travel expenses. My biggest encouragers have been my family, and particularly my sister Muriel Gudgin and her family. They have sent almost daily emails and followed my progress closely.

Finally, there are four people who won't be attending my graduation but whom I owe a great deal to: My parents, David and Jean Pearce, and also Sylvia Hedinger and Dodi Mason. They have each been a huge encouragement to me and I miss them very much. Although they aren't here physically to cheer me on now, I know that they are in fact doing just that and I am so very grateful for all they have done in getting me to this point.

It goes without saying that despite all this help and encouragement, there are probably still a number of errors in this text. I take full responsibility for those and am happy for feedback in order to correct them.

Contents

Abstract 2
Acknowledgements 3

Chapter 1 Introduction 10
1.1 Tone, voicing and foot structure in Kera 10
1.2 Claims of this thesis 11
1.3 Kera background 16
1.4 Basic phonology and morphology 17
1.4.1 Consonants 17
1.4.2 Vowels 19
1.4.3 Prosodic Structure 20
1.4.4 Quantity Sensitivity 20
1.4.5 Tone and voicing 21
1.4.6 Kera morphology 22
1.5 Theoretical basis 25
1.6 Conclusion 26

Chapter 2 Foot structure 27
2.1 Introduction 27
2.1.1 Basic facts 28
2.2. Foot structure and arguments for a foot 30
2.2.1 Deletion and lengthening of vowels in /CVCV/ words 30
2.2.1.1 Other words which could contain (CVCV) 37
2.2.1.2 Stray syllables 41
2.2.2 Duration 46
2.2.3 Vowel quality 50
2.2.3.1 Undershoot or allophones? 53
2.2.4 Intensity 60
2.2.5 Vowel harmony 61
2.2.6 Tone spreading 62
2.2.7 Perception 63
2.2.8 Syllabic nasals 64

2.2.9 Epenthetic vowels 65
2.2.10 Minimal binarity requirement 66
2.2.11 Conclusion concerning Kera foot structure 70
2.3 OT analysis on foot structure 72
2.3.1 Constraints on types of feet 72
2.3.2 Constraints concerning the position in the phrase 74
2.3.3 Constraints on phrase-medial position 80
2.3.4 Non-footed epenthetic vowels 81
2.3.5 Summary 86
2.4 Obstruent release 87
2.5 OT analysis of ATR allophones 90
2.6 Conclusion 91

Chapter 3 Vowel harmony and foot interaction 93
3.1 Introduction 93
3.1. Summary of types of harmony 96
3.2.1. Epenthesis 97
3.2.2 Height harmony 99
3.2.3 Fronting/Rounding harmony 104
3.2.4. Fronting 105
3.2.5 Motivation for right to left directionality 108
3.2.6. Total harmony 109
3.3 Vowel harmony and domains 113
3.3.1 Vowel harmony domains 114
3.3.2 Final stray syllables 116
3.3.3 Other non-parsed segments 120
3.4 OT analysis of vowel harmony 122
3.4.1 Epenthesis 123
3.4.2 Height harmony 125
3.4.3 Front and rounding harmony 127
3.4.4 Fronting 133
3.4.5 Total harmony 135
3.5 Acoustic measurements and discussion 136
3.5.1 Vowel harmony or co-articulation in Kera? 136
3.5.2 Examples of vowel harmony types 140
3.6 Motivation for vowel harmony in Kera 146

3.7 Literature on vowel systems and vowel harmony 148
3.7.1 Templatic systems 148
3.7.2 The foot as a domain 150
3.7.3 Chadic prosodies 150
3.7.4 Direction and dominance 153
3.8 Conclusion 154

Chapter 4 Tone and foot interaction 155
4.1 Introduction 155
4.2 Basic facts of Kera tone 156
4.2.1 Consonants and tone interaction 158
4.3 Survey of tone and foot interaction 162
4.3.1 Across language interaction of tone and feet 162
4.3.2 Interaction of tone and feet in Chadic languages 164
4.3.3 Kera Tone and Foot Interaction 166
4.4 Further spreading of tones between roots and suffixes 173
4.4.1 Nouns 173
4.4.2 Inalienable Nouns 174
4.4.3 Verb suffixes 176
4.4.4. Effects of the suffixes -n and -T. 180
4.4.5 Diachronic account for verbs 183
4.5 OT analysis of tone spreading 183
4.6 Discussion of the tone bearing unit 188
4.7 Conclusion 191

Chapter 5 Tone and voicing interaction: Experimental evidence 192
5.1 Introduction 192
5.2 Voicing and Tonogenesis 192
5.2.1 VOT contrasts 193
5.2.2 Tonogenesis 194
5.2.3 Depressor consonants 200
5.3 Tonogenesis and depressor consonants in Chadic 201
5.4 Kera tonogenesis 207
5.5 Relative contribution of VOT and F0 in Kera: Perception experiments 213
5.5.1 Perception test method 213
5.5.2 Perception test results – comparison of languages 215
5.5.2.1 English 215

5.5.2.2 Kera 216
5.5.2.3 Comparison between languages 218
5.5.2.4 Comparison between French and Kera 222
5.5.3 Perception test results – comparison of Kera populations 224
5.5.3.1 Eeffects of location 224
5.5.3.2 Effects of gender 225
5.5.3.3 Effects of literacy 226
5.5.3.4 Summary of perception results 228
5.6 Measurements on production of VOT and F0 across Kera groups 230
5.6.1 Overall trends in production 230
5.6.2 Normalised graphs 232
5.6.3 Is the tonal contrast maintained in sonorant words? 240
5.6.4 Is French pronunciation affected in Kera speakers? 241
5.6.5 Is VOT varying with F0 or tone? 244
5.7 Discussion 246
5.7.1 Enhancement 247
5.7.2 What difference does gender make? 253
5.7.3 Is there a critical age? 262
5.8 Conclusion 268

Chapter 6 Tone and voicing interaction: Theoretical issues 271
6.1 Introduction 271
6.2 Claims of voice spreading in Kera 272
6.3. Counter-evidence for voice spreading claim 274
6.3.1 Counter-evidence from affixes 274
6.3.2. Counter-evidence from French loans 279
6.3.3 Counter-evidence from statistical analysis of lexicon 280
6.4 Laryngeal feature models 284
6.4.1 Description of laryngeal gestures 285
6.4.2 Laryngeal Features and models 290
6.4.2.1 Halle and Stevens (1971) 290
6.4.2.2 Yip (1980), Bao (1990), Duanmu (1990) 291
6.4.2.3 Bao (1999) 294
6.4.2.4 Models including [voice] 294
6.4.2.5 Avery and Idsardi (2001, forthcoming) 296
6.5 Grammar of Kera diachronic and synchronic stages 300

6.5.1 Diachronic stages of Kera development 301
6.5.2 Synchronic Kera dialects 303
6.5.3 OT analysis of tone with laryngeal features 306
6.6. Issues raised 308
6.6.1 The reanalysis of M tone 308
6.6.2 Extending the analysis to the foot 308
6.6.2.1 The foot as 'feature-bearing-unit' 316
6.6.2.2 Foot as FBU in Optimality Theory 321
6.6.2.3 Disyllabic feet with two tones 325
6.6.2.3. Summary 329
6.7. Conclusion 331

Chapter 7 Conclusion 333

Bibliography 338

Appendix 1 Inalienable nouns 361
Appendix 2 Further VOT/FO plots 362
Appendix 3 Further data on voicing and tone statistics 364
Appendix 4 Kera folk story – annotated 365

Chapter 1
Introduction

1.1 Tone, voicing and foot structure in Kera

This thesis investigates the interaction of tone with voicing and foot structure in Kera (a Chadic language). Kera is not the type of language where surface stress provides clear evidence for foot structure. Nevertheless, we will find evidence for the foot with measurements of duration, intensity and vowel quality, noting that the iambic foot acts as a domain for spreading in both tone spreading and vowel harmony. We will look in detail at the various types of vowel harmony and the role of the foot in the harmony domains, noting particularly the typologically rare height dominant system and the fronting harmony with the foot as a domain. This will be followed with an investigation of the tonal system. Kera is unusual in combining a tone system with a partially independent metrical system based on iambs. In words containing more than one foot, the foot is the tone bearing unit (TBU), but in shorter words, the TBU is the syllable. Throughout the thesis the framework of Optimality Theory is applied, but the majority of the observations made are not dependent on OT.

Detailed acoustic measurements (including voicing perception and tonal production experiments) are used as a basis for the phonological analysis, particularly in the chapters on tone. These show that Kera speakers, unlike English and French, use the fundamental frequency as the principle cue to "voicing" contrast. Voice onset time (VOT) has only a minor role. Historically, tones probably developed from voicing through a process of tonogenesis, but synchronically, the feature [voice] is no longer contrastive and VOT is used in an enhancing role. Some linguists have claimed that Kera is a key example for their controversial theory of long-distance voicing spread. But as [voice] is not part of Kera phonology, this thesis undermines the voice spreading claim. Where phonetic "voicing" is found, this is in most dialects a supporting cue to the tonal contrast.

An important finding from the experiments is that the phonological grammars are different between village women, men moving to town and town men. These differences are attributed to French contact. The interaction between Kera tone and voicing and contact with French have produced changes from a 2-way voicing contrast, through a 3-way tonal contrast, to a 2-way voicing contrast plus another contrast with short VOT. These diachronic and synchronic tone/voicing facts are analysed using laryngeal features and Optimality Theory. We will consider various systems of laryngeal features and conclude that a slightly modified form of the Halle and Stevens (1971) model suits the Kera facts as well as any of the more recent models.

This thesis provides a body of new data, detailed acoustic measurements, and an analysis incorporating current theoretical issues in phonology, which make it of interest to Africanists and theoreticians alike.

The rest of this introductory chapter is structured as follows: In §1.2, the claims of this thesis are given in a little more detail with a brief overview of each chapter and the most salient examples. In §1.3, essential background on the Kera situation is given and this is followed in §1.4 by a basic overview of the phonology and morphology, focusing mainly on aspects which are relevant to the rest of this thesis. Finally in §1.5, there is a short discussion of the theoretical basis for this thesis.

1.2 Claims of this thesis

This thesis is built on two fundamentally prosodic phenomena in Kera: the tonal system and the iambic foot. We consider how they relate to each other and we investigate how the tonal system relates to voicing, and the foot structure to vowel harmony. In the process of this investigation, we will see the contribution of disciplines other than phonology, notably acoustic phonetics (with perception and production tests) and sociolinguistics (with a look at the effects of contact and gender on changes in tonal and voicing contrast). But the central theme will be the important roles played by the tonal system and the iambic foot.

Chapter 2 will argue for the existence of an iambic foot structure in Kera and acoustic measurements will be used as evidence of the changes in quality and quantity that come about through the parsing process. The evidence is not seen so much in stress placement as in quantity contrasts and in connections between quantity and vowel allophones. We also see clear evidence for the foot in structural changes which occur in order to favour well-formed iambic feet. The main evidence in this chapter comes from /CVCV/ inputs which cannot surface as [CVCV] in Kera. Either the final vowel is deleted to form a monosyllabic foot (CVC), or the final vowel is lengthened to form a disyllabic foot (CVCV:). In this and following examples, parentheses indicate the foot boundaries.

(1) For an input of /CVCV/, illustrated with the input /bɛgɛ/:

With definite article, [-ŋ]: no change (CVCVŋ)			
	[(bègɛ́ŋ)]	*animal-DEF*	'the animals'
Phrase medial:	final vowel deletion gives (CVC)		
	[(bèg) (núu)tú][1]	*animal his*	'his animals'
Phrase final:	2nd vowel lengthening gives (CVCV:)		
	[(bègɛ́:)]	*animal*	'animals'

[1] I will discuss the issue of unfooted syllables in chapter 2.

Having established the evidence for the existence of the foot in chapter 2, we will move on in chapter 3 to examine the complex system of vowel harmony. This involves total harmony, height harmony, fronting and rounding harmony and a further type of fronting harmony with the foot as the domain of spreading. Between these types of harmony, there are various triggers, targets and domains. The foot structure has a direct or indirect role to play in a number of them. There are two areas which are of typological interest here: the height dominant system, and the fronting harmony with the foot as the domain of spreading. Both of these are rare across the world's languages. We will investigate each of the harmony systems outlined below and the role of the foot in defining the domain for some of them (including those which have the Prosodic Word as the domain. The Prosodic Word is made up of all of the feet in the word, ignoring any unfooted syllables). The Morphophonemic Word includes the root and any affixes.

(2) *Vowel harmony types in Kera*

Harmony	**Direction**	**Target**	**Trigger**	**Domain**
Epenthetic feature-filling	← if possible	epenthetic V	underlying V	PrWd
Height	↔	all V	high V	MWd
Fronting and rounding	←	high central V	high fr/rd (suffix) V	PrWd
Fronting	←	central V	front (suffix) V	Foot
Total	←	all V (not suffix)	last head V (not suffix)	PrWd in stem

In chapter 4, we will move on to examine the interaction between the foot and tone. In shorter words, the syllable appears to be the tone bearing unit, but in longer words, the tone bearing unit appears to be the foot. The examples below show that in words with only one foot (3a), the tones on each syllable can be different, but in words with more than one foot (3b and c), the tones within the foot agree.

(3) *Tone distribution in words with a varying number of feet*

a. One foot, two tones:

(lèmún) 'lemon', (lógɔ̀m) 'humidity', (kítīr) 'moon'

b. Two feet (two syllables), two tones:

(gɨɨ)(gúr) 'chickens', (máa)(hùr) 'bass flute', (kɔ́s)(lɔ̄m) 'laziness'

c. Two feet (three syllables), two tones:

(gə̀dàa)(mɔ́:) 'horse', (dàk)(tə́láw) 'bird'

But: *(gə̀táa)(mɔ́:), *(dàg)(də̀láw)

(kə́sáa)(bɔ̀:) 'locust', (mán)(də̀hàŋ) 'sack'

But: *(kə́zàa)(bɔ̀:), *(mán)(tə́hàŋ)

(kúɓúr)(sī:) 'coal', (sáa)(tə̄rāw) 'cat'

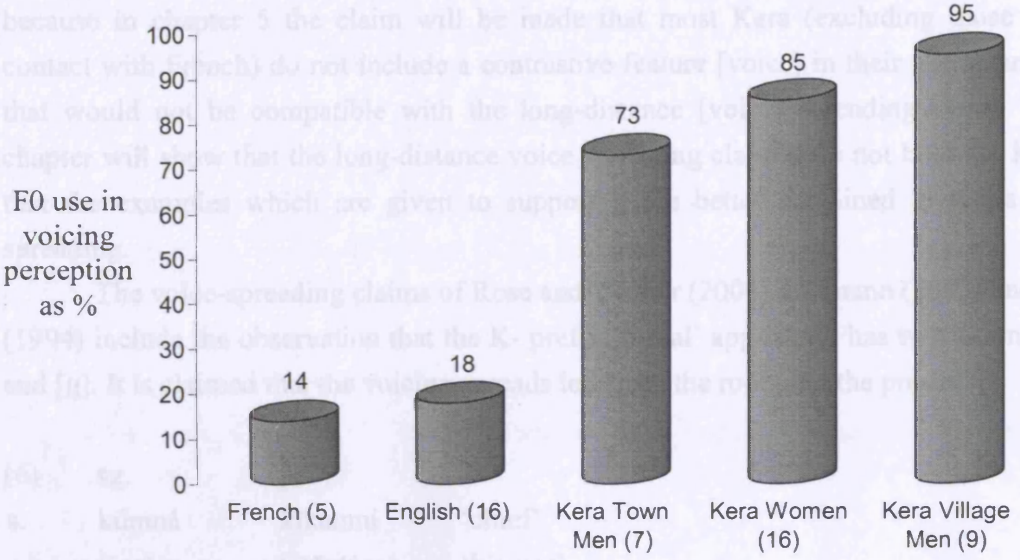
But: *(kúɓūr)(sī:), *(sáa)(tə́rāw)

We will examine the reasons for this apparent restriction in longer words and the theoretical implications if we accept the foot as a tone bearing unit.

In chapter 5, we will stay with tone, but we will now consider the interaction between tone and voicing. We will look in some detail at this relationship with the help of acoustic measurements and perception and production experiments. These will lead us to explore both how tone may have developed in Kera and further developments which are taking place synchronically through language contact. We will note that location and gender significantly affect the results and we will consider some of the current sociolinguistic theories which may be able to account for the manner and speed of change.

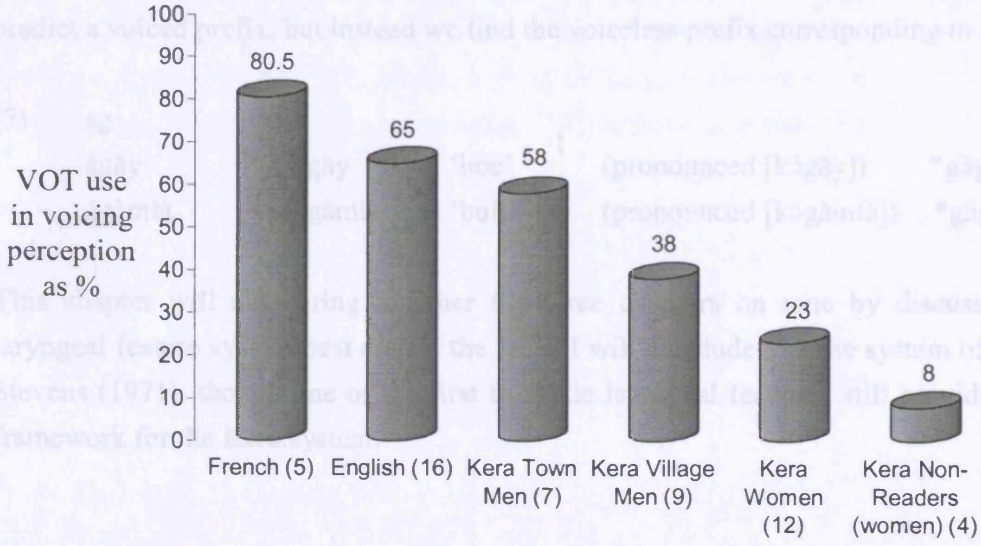
In this chapter, many of the results will be given in terms of a plot of the voice onset time (VOT) against the fundamental frequency (F0). The following graphs highlight the different usage of VOT and F0 in perception tests between the three languages Kera, French and English, and also between different Kera populations. As expected, F0 use in French and English is lower than its use in Kera, which is a tone language. But these results show just how important the tonal information is to the Kera speaker, even though the test was designed to encourage him or her to look for a voicing difference. It is also of note that the Kera who live in a village location make more use of F0 than those in town.

(4) *Range of voicing perception judgements based on changes in F0 (as percentage)*



The VOT graph below is roughly an inverse of the F0 graph, but note the range of VOT use among the different Kera populations. We will discover that the main influence on VOT use is the contact with French. For town Kera who have the most contact, the VOT role is of great importance. We will compare these results with production results and again look at the role of gender and language contact.

(5) *Range of voicing perception judgements based on changes in VOT*



Finally, in chapter 6, we will look at claims which have been made for Kera concerning long-distance voicing spread. The voice spreading claim is of relevance to this thesis because in chapter 5 the claim will be made that most Kera (excluding those most in contact with French) do not include a contrastive feature [voice] in their grammar. If true, that would not be compatible with the long-distance [voice] spreading claim. But this chapter will show that the long-distance voice spreading claim does not hold for Kera and that the examples which are given to support it are better explained in terms of tone spreading.

The voice-spreading claims of Rose and Walker (2004), Uffmann (2003) and Odden (1994) include the observation that the K- prefix 'plural' apparently has two alternants: [k] and [g]. It is claimed that the voicing spreads left from the root onto the prefix.

(6)	sg.	pl.	
a.	kúmná	kīkámní	'chief'
	tāatá	kītāatáw	'big pot'
	táasā	kətáasāw	'cup'
b.	bɨrwá	gɨbɨrwáŋ	'white'
	dàarà	gədàarà	'friend'
	àzrá	gàzráw	'gazelle'

However, I will show that if the first syllable has a H tone, the prefix will have a long VOT and will therefore be perceived as voiceless. So it is the tone of the syllable and not the voicing which is the salient property. In (7), the long distance voice spreading claim would predict a voiced prefix, but instead we find the voiceless prefix corresponding to H tone.

(7)	sg	pl			
	ágày	k-ágày	'hoe'	(pronounced [kə́gày])	*gə́gày
	ágàmlà	k-ágàmlà	'bull'	(pronounced [kə́gàmlà])	*gə́gàmlà

This chapter will also bring together the three chapters on tone by discussing which laryngeal feature system best covers the facts. I will conclude that the system of Halle and Stevens (1971), though one of the first to tackle laryngeal features, still provides a useful framework for the Kera system.

(8) *Halle and Stevens (1971), features [±stiff] and [±slack]*

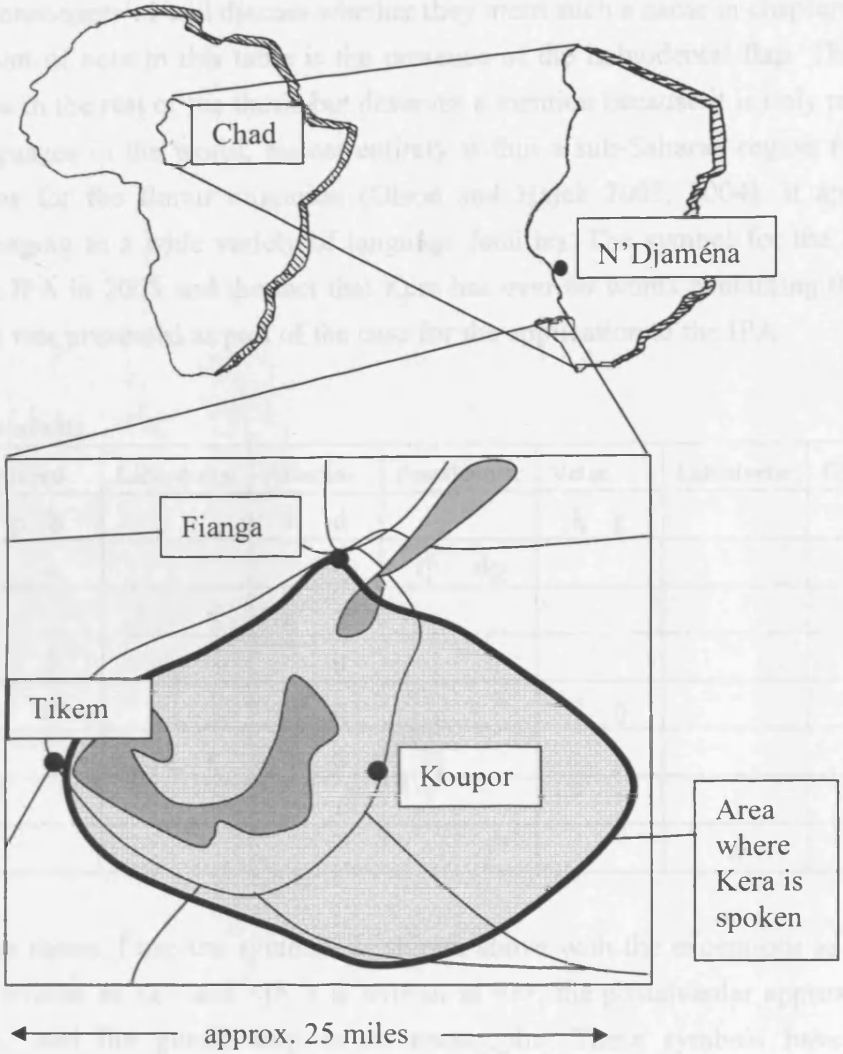
+ stiff	-stiff,-slack	+ slack
voiceless obstruent H tone	 M tone	voiced obstruent L tone

Together, this thesis provides an analysis of Kera foot structure, vowel harmony and tone which incorporates current theoretical issues in phonology, detailed acoustic measurements and a body of new data which will be of interest to descriptive and theoretical linguists alike. It raises many questions for future research into the relationships between metrical, tonal and harmonic structures, the nature of laryngeal features, the relationship between voicing and tone, and also the largely unexplored typological richness that appears to be present in Chadic languages.

1.3 Kera background

Kera is an Eastern Chadic language spoken by about 50,000 people in Southern Chad and parts of Cameroon. Previously published material on Kera includes a grammar, lexicon, collection of texts, anthropological data and some linguistic papers by Ebert (1974, 1975, 1976, 1977, 1979, 2003) and Pearce (1999, 2005a,b, 2006a,b,c, 2007a,b). My own contact with the Kera began in 1992, and I stayed in the area until 2002 under the auspices of SIL International. I then made two further field trips in 2004 and 2006 for the purpose of collecting data for this thesis. I lived in the village of Koupor in the Sub-prefecture of Fianga. Roughly 40,000 Kera live in rural settings and the remaining 10,000 have migrated to towns in Cameroon and Chad where they generally live in Kera speaking communities that also speak French. The literacy rate among the Kera is rising sharply and is probably between 10 and 20% in Kera, French or both languages. The New Testament in Kera was distributed in 2006. There are approximately 30 other books written in Kera.

(9) *Map of the Kera region in Chad*



1.4 Basic phonology and morphology

Space does not permit a complete phonological description of Kera, but some of the basics are given here, with the emphasis on those areas which are relevant to later discussions.

1.4.1 Consonants

The table below shows the Kera consonants. The first three rows are collectively referred to as 'obstruents'. In this table they are divided into voiced and voiceless counterparts. In most dialects of Kera the voicing is no longer the most salient cue for ascertaining the contrast between these pairs. That role has been given instead to the tone of the syllable. This will be discussed in detail in chapters 4-6. At this point the voicing is shown because it appears

in the phonetic transcriptions even if not contrastive. In earlier papers written on Kera, the assumption was made that there is a voicing contrast, so all of the obstruents listed below were given a phonemic status. The so called 'voiced' obstruents are sometimes referred to as 'depressor consonants'. I will discuss whether they merit such a name in chapters 4-6.

One point of note in this table is the presence of the Labiodental flap. This sound does not feature in the rest of the thesis but deserves a mention because it is only present in around 80 languages in the world, almost entirely within a sub-Saharan region following supposed routes for the Bantu migration (Olson and Hajek 2003, 2004). It appears in languages belonging to a wide variety of language families. The symbol for the flap was adopted by the IPA in 2005 and the fact that Kera has over 60 words containing the sound (Pearce 2005c) was presented as part of the case for the application to the IPA.

(10) *Kera consonants*

	Bilabial	Labiodental	Alveolar	Postalveolar	Velar	Labialvelar	Glottal
Plosive	p b		t d		k g		ʔ
Affricate				tʃ dʒ			
Fricative		f v	s z				h
Implosive	ɓ		ɗ				
Nasal	m		n		ŋ		
Flap		ⱱ	ɾ				
Lat. approx.			l				
Approximant				j		w	

Throughout this thesis, I use the symbols as shown above with the exceptions as follows: Affricates are written as <c> and <j>, ɾ is written as <r>, the postalveolar approximant is written as <y> and the glottal stop as an apostrophe. These symbols have general acceptance across Africa, and are therefore of more help to Africanists.

The glottal stop and glottal fricative have a limited distribution, but minimal pairs exist which contrast these segments with their absence.

(11) *Glottal sounds*

bì'ì 'perish' bìi 'come' dɔ̀' 'burn' dɔ̀ɔ 'grab'

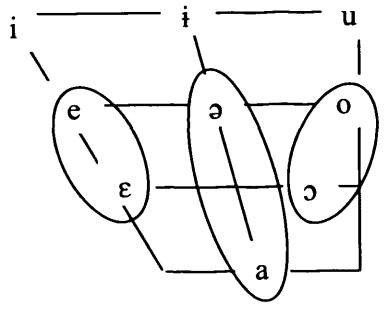
hámɛ́: 'eat' ámɛ́: 'guard'

The glottal segments also affect neighbouring segments less than other consonants with regard to tones, duration and quality because they do not condition formant transitions (Borroff 2007, Browman and Goldstein 2000). This makes a difference to the quality of the

vowel, and the lack of duration of the glottal stop may well lead to a phonetic lengthening of the vowel that follows.

1.4.2 Vowels

(12) *Kera vowels*



lengthened vowels:
i: ɨ: u: ɛ: a: ɔ:

nasalised vowels (short and long):
ĩ ɨ̃ ɛ̃ ã ɔ̃

The circles indicate allophones of one phoneme. In each case, the more closed vowel can appear only as the nucleus of the non-head syllable in an iambic foot while the more open vowel appears in head position and elsewhere. Throughout this thesis, the more closed alternant is given the feature [+ATR] and the more open counterpart [-ATR]. As well as this difference in quality, the duration of vowels is also affected by whether they are in head or non-head position.

Ebert (1979) treated the ə/a alternation as a special case of a process of dissimilation which changed every other /a/ into [ə]. She did not connect this to the same alternations between e/ɛ and o/ɔ presumably because the F1 difference between them is less evident, meaning that a reliable description needs to be based on acoustic measurements. Unfortunately the apparent special case for the low vowel /a/ has led several linguists including Buckley (1997), Suzuki (1998), de Lacy (2004a) and Archangeli and Pulleyblank (2007) to give this Kera example as support for theories of dissimilation processes involving low vowels, although all of these authors cite other languages as well as Kera. It is true that [a] and [ə] are often found alternating in words, but this is only because of the metrical structure of Kera which encourages a weak strong alternation. Once we have observed that the three non-high vowels act in a similar way, with the respective allophones appearing in the same locations, it is easier to explain the quality in terms of the position in the foot (or, as we will see in chapter 2, duration) rather than dissimilation processes.

As well as the segments referred to above, we will be considering epenthetic vowels and transitional vowels. Epenthetic vowels are vowels that carry a certain amount of weight in the output, but which are not present in the input. I will argue that these vowels can carry weight in Kera because they can be head vowels, but that they cannot carry two morae, as

seen by the fact that they cannot lengthen. Transitions are sounds that are vowel-like in quality but which have no phonological status. They appear between two consonants while moving between gestures, but they have a limited duration and should not be included in either the input or output form.

1.4.3 Prosodic structure

The structure of the syllable is as follows: (C)V, (C)V:, (C)VC, with the latter two analysed as being heavy syllables. A few words also have a final syllable of the form (C)Ṇ, such as dùugŋ 'evening'.[2] This thesis makes the claim that Kera has an iambic foot made up of one or two syllables. The non-head syllable is always light and the head syllable is always heavy. Lexical words contain at least one foot. Higher prosodic levels will also play a role, including the Prosodic Word which consists of all of the feet in the word, and the Phonological Phrase which aligns itself with the right edges of syntactic XP phrases. There are also intonational and durational effects at the Intonational Phrase level, but these effects will only be referred to briefly in this thesis.

1.4.4 Quantity sensitivity

Kera is a weight sensitive language where vowel length is contrastive, as seen in the following minimal pairs. In these examples, the foot structure has been marked with parenthesis. The changes in quality in head and non-head vowels will be discussed in chapter 2. At this point, the main purpose of these examples is to show that length is contrastive.

(13)	*Verbs*:	(céré:) 'libation'	(céɛ)(ré:)	'rip open'
		(ɗéré:) 'gathering fruit'	(ɗéɛ)(ré:)	'pour liquid'
		(hámé:)'eat'	(hàa)(mè:)	'bend metal'
		(hòlè:) 'skin an animal'	(hɔ̀ɔ)(lè:)	're-warm'

[2] The syllabic nasal is found in the first person possessive suffix on nouns, -ṇ. Note also that the Kera word for 'mine' has 2 versions: *kətan* and *katṇ*. The second of these has a syllabic –ṇ. For the 2 m possessive –m, there is no syllabic version and likewise there is only one form for 'yours', i.e. *kətam*. Although verb object and noun suffixes are very similar, the 1 sg suffix in verbs is not syllabic. Of the other lexical items that contain the syllabic nasal, several appear to be based on the same template: *dèɛgn* 'yesterday', *dùugŋ* 'evening', *ɗɩgŋ* 'afternoon', note also *dàynà* 'today' and *dìbìinì* 'tomorrow'.

Other pairs:	(dìrì:)	'in them'	(dìi)(rì:)	'with them'
	(dùrù:)	'in him'	(dùu)(rù:)	'with him'
	(dɨ̀rɨ̀:)	'in her'	(dɨ̀ɨ)(rɨ̀:)	'with her'
	(kə́sáw)	'sauce'	(káa)(sáw)	'millet'

In this thesis, length will generally be indicated with a double letter, but where the length has presumably been increased from the underlying form, this lengthening process is indicated with a colon. There is no phonetic difference between the durations of these two types of length so the notation is used simply to aid in the analysis.

1.4.5 Tone and voicing

There are three phonemic tones in Kera with an apparent maximum of two tones per monomorphemic word. In nouns, there are 7 surface melodies while verbs are restricted to 4. Most of the tone is lexical, but there is also some grammatical tone.

Although several linguists have claimed that voicing contrasts exist in Kera, this claim is disputed in this thesis. Regardless of the phonological status of voicing, the phonetic status is in question as the segments which are labeled as 'voiced' do not have true voicing. As is the case in English, the difference between so called voiced and voiceless stops is in terms of Voice Onset Time (VOT). VOT is defined as the time between the release of the stop consonant and the onset of voicing (Lisker and Abramson 1964). We will make extensive use of this measurement to examine the exact relationship between voicing and tone. My measurements will also refer to the fundamental frequency (F0) which is measured in Hz and which gives us a measure of pitch.

Where tone is marked by an accent on examples, or a capital letter below the word, the following system will be used: ´ High H, ¯ Mid M, ` Low L. The absence of a tone mark does not mean Mid. It simply means that the tone is not relevant to the example and has been excluded so as not to complicate the issue being discussed. Where long vowels are indicated with a repeated letter, the tone is marked only on the first vowel. Kera has no contour tones, so this should be interpreted as one tone which applies to the whole syllable.

Particularly in chapter 5, I will refer to different dialects of Kera. These dialects differ in their use of VOT and F0. Throughout the thesis I will refer to recorded examples from Kera speakers. If the dialect is not referred to or if I label the dialect as the 'Standard dialect' of Kera, this means that the speaker was raised in a village location, but moved to a town as an adult. I have called this the 'Standard' dialect because it is the dialect of most of the speakers who were recorded and because it represents a rough average of the types of dialect which are spoken. Whenever the specific dialect is an issue,

a full description of the assumptions being made will be given together with results from each of the dialect groupings.

1.4.6 Kera morphology

The most common noun phrase affix is the definite article –ŋ which appears only on vowel-final words. The addition of the –ŋ makes the final syllable heavy. This suffix works at phrase level and is best analysed as a clitic.[3] Most nouns have no morphemes to mark masculine, feminine or plural. But for certain nouns only, a rather irregular system of masculine, feminine and plural morphemes can be seen. This system is no longer productive, but in some nouns or adjectives we can compare roots with all three affixes.

(14)	m /k-/	f /t-/	pl /k- -aŋ/ or /k- -aw/	
	kīmpílí:	tēmpélá:	kēmpélɛ́ŋ	'long'
	kísírkí	sárká	kə́sárkáŋ	'black'
	kɔ̄ɔcɛ́	cɪ̄ɪcɪ́	kɔ̄ɔcɔ́ŋ	'little'
	pɪ̄ɪrɪ̄ŋkí	tɪ̄ɪrɪ̄ŋká	kəpāarāŋkáw	'old'
		táasā	kə́táasāw	'cups'
	jàaŋà		gəjàaŋàw	'seat'
		dàygà	gədàayáw	'jug'

Kera has a small group of words that are called 'inalienable nouns'. These words are all within the semantic domain of body parts or close relatives. Noun suffixes can be added to inalienable nouns to form a possessive.

[3] There are a few other affixes which are now frozen in place in the noun. a- and –a are often used for location, e.g. *alúma* 'market' and a- is often used for animals, e.g. *akɔ́rkórɔ́:* 'duck'. This prefix is sometimes outside of the parsing of the foot. It is reported to be a loan from a neighbouring language, which probably means it is undergoing change. The tone on this prefix is also often variable and so is left unmarked. There are two more frozen forms: -ki (m) and –ka (f). Words taking these suffixes can no longer appear alone without the suffix. e.g. *kúpúrkí* 'bull', *tāamə́ká:* 'sheep'. These frozen forms do not undergo vowel harmony. They can also give rise to unusual word tonal patterns such as tɪ̄ɪrɪ̄ŋká.

(15) *Inalienable noun affixes*[4]

(possessive)	
1 sg	-n̩
2 m sg	-m̀
2 f sg	-ì
3 m sg	-u
3 f sg	-a
2 pl	-ŋ̀
3 pl	-i

The inalienable noun affixes are similar to the verb object markers which are listed below in (16), but there are tonal differences.

Verb suffixes denote the aspect, mood or object (direct or indirect). Similar suffixes denote a possessive when added to inalienable nouns. The noun and verb suffixes are as follows:

(16) *Exhaustive set of verb affixes*

(mood)		(aspect)	(medial / final)	(object)	
iterative	-t́	imperfective	ø /-ɛ	1 sg	-ǹ
		perfective	-n / -ŋ	2 m sg	-m̀
		imperative	ø	2 f sg	-ỳ/-ì[5]
				3 m sg	-u
				3 f sg	-a
				2 pl	-ŋ̀
				3 pl	-y/-i

The imperative is also marked with a separate word, but it is included in this list as the imperative shows us the form of the root without the effects of vowel harmony. Between 1 and 4 suffixes can combine together. For example: *mirk-t-n-m* > *mirkitnim* 'greeted you repeatedly'.

---

[4] Appendix 1 contains a complete list of inalienable nouns. The 1 pl forms have no affix. They are separate words which do not undergo vowel harmony with the root.

[5] The 2 f sg and 3 pl suffixes have two forms. In some words the segments differ. But in many words, the two forms differ only by tone. -y is more common than -i. More research is needed on this with dialect, height and frontness of vowel, and foot structure possibly playing a role. Some speakers show considerable variation.

The words can contain at most one vowel suffix, so there is no case where two vowel suffixes are trying to spread conflicting features. The only possible conflict between features comes from the root vowel and suffix vowel. Epenthetic vowels which are added to make the CV structure permissible will always match one of these.

With consonant suffixes, an epenthetic vowel is inserted. The quality of the vowel matches that of the root.

(17) *Verbs with imperfective ø+ 1 sg -n*

root	ø + -n 'is ... me'
i mírk- 'to greet'	mīrkīn 'is greeting me'
ɨ wɨ́t- 'to hit'	wītīn
u bùus- 'to divorce'	bùusùn
ɔ gɔ̀l- 'to look'	gɔ̀lɔ̀n
a bàad- 'to wash'	bàadan
e jɛ̀ɛr- 'to write'	jɛ̀ɛrɛ̀n

This same process is seen in longer words such as *mírk-t-n-n* > *mīrkītnīn* 'greeted me (habitual)'.

Vowel suffixes undergo height harmony if the root vowel is high and the suffix underlyingly low. The root vowel also undergoes height harmony when the suffix is high. (18) includes other vowel harmony processes which will be discussed further in chapter 3.

(18) *Imperfective with ø+ vowel suffix*

root	ø -i	ø -u	ø -a
i mírk- 'to greet'	mīrkī	mírkú	mírkí
ɨ wɨ́t - 'to hit'	wītī:	wútú:	wítí:
u gùn- 'to wake'	gùnùy	gùnù:	gùnì:
ɔ t'ɔ́p- 'to gather'	tūpūy	túpú:	tópá:
a bàad- 'to wash'	bɨ̀ɨdɨ̀y	bɨ̀ɨdù	bàadà
ɛ jɛ̀ɛr- 'to write'	jìirì	jìirù	jɛ̀ɛrà

In longer words, epenthetic vowels may be added. The epenthetic vowels agree with the suffix vowel. For example: *mirk-t-u* > *mirkutu:* 'I greeted him (habitual)'. Details of the quality choice for epenthetic vowels are given in chapter 3.

Many tenses, aspects and moods are expressed in Kera with separate words, which do not normally undergo vowel harmony with the verb. Compound words are not bound by vowel harmony considerations, nor are vowel prefixes.

1.5 Theoretical basis

The theoretical basis for this thesis relies on an outlook like that employed by the Laboratory Phonology tradition which incorporates both phonological theory and acoustic phonetics data. My bias is towards phonology, but I believe in balancing well applied theory with acoustic measurements and good statistical analysis and in keeping an open mind about the exact nature of the phonetics/phonology interface. In this respect I am influenced by phonologists and phoneticians who work on topics around the interface without necessarily agreeing with all of their conclusions. The linguists that have influenced my thinking the most for this thesis are Juliette Blevins on language change, Kenneth Stevens, Yi Xu and Moira Yip on tone and enhancing cues, Douglas Pulleyblank on vowel harmony, Paul de Lacy and Bruce Hayes on metrical structure, Aaron Shryock on Chadic phonetics, and Larry Hyman on African linguistics.

Although trained first in descriptive linguistics, I find that a description-only approach to the phonology is not satisfying because it ignores contributions to typology and does not investigate unusual patterns enough. So for example, Kera was assumed to have a [voice] feature simply because all Chadic languages have been described in terms of a [voice] feature. The true, and much more interesting, situation in Kera could not be discovered without a combination of careful measurements and the application of various theories to explain the facts.

Conversely, I would also stress the importance of first hand, reliable data. Some of the claims which I argue against in this thesis are based on various linguists' interpretations of notes from other linguists. This can be dangerous, so this thesis aims to give a body of new, first hand data to prove the claims which are made.

I have attempted to arrange the conditions for experiments so they can be as reliable as possible, but it should be remembered that perfect conditions are difficult to maintain in a field situation. Some recordings had to be made outside in order for there to be enough light, and this in turn meant that the recordings are augmented with the noise of wind, birds, goats, etc. Likewise when testing for voicing perception, allowances had to be made for women who had not learnt to read. They all successfully interpreted my drawings as representing the words in question, but the reader should remember these conditions when considering the conclusions that I draw. There are no Kera speakers in the UK, so all data collection came from field trips plus three recordings by helpful SIL colleagues in Chad. In

each case, I aimed to get enough samples of the recordings and judgements that there could be no real doubt of the significance of the tests even given the conditions.

The recording equipment used included a Marantz PMD660 digital recorder, a Toshiba Satellite computer with external microphone and for a few recordings, a Sony Minidisk. The Marantz recorder was used mainly when mains power was not available. A sampling rate of at least 44,000 Hz was used with all of the equipment. For the analysis, the main software used was: PRAAT (Boersma and Weenink), SFS Win (Huckvale), and Speech Analyser 2.6 (SIL International). More details concerning the equipment and testing conditions are given in chapter 5.

Optimality Theory is used as the main framework for the phonological analysis because I see it as a helpful framework which encourages the search for well grounded constraints and which helps in the understanding of why certain patterns might emerge. All of the constraints used in this thesis are reasonably standard constraints and no big new claims are made within the theory. It is being used more as a tool to present the grammars and the typology. I happen to like the theory, but I am not using this thesis to defend it particularly.

One final note on features is in order. In earlier chapters, the standard notation for tone is used with H, M and L for the three tones. In chapter 6 however, other features are discussed which have an effect on the tone, most noticeably the [stiff] and [slack] features of Halle and Stevens (1971). If I were to adopt these laryngeal features for Kera, then that would technically mean that all of the analysis of chapters 2-5 would have to be revised in the light of these features. However, H, M and L are still very useful as a kind of shorthand, and for this reason, I have not re-written the earlier chapters. I believe that the conclusions for the earlier chapters would be the same whatever the notation.

1.6 Conclusion

This thesis aims to give enough of a description of the phonology of Kera, using new first-hand data, that descriptive linguists and Chadicists will find plenty to interest them. It also aims to give enough detailed acoustic measurements, and careful statistical analysis that acoustic phoneticians will find it of interest. Finally, it hopes to address current theoretical issues and questions of typology and sociolinguistics making it of interest to theoreticians in the fields of phonology and sociolinguistics. It is my hope that, regardless of the particular interest of the reader, they will be left sharing my love and fascination of the beautiful Kera language, and with a desire to know more about the issues that are raised in this thesis.

Chapter 2
Foot structure

2.1 Introduction

Throughout this thesis, I claim that Kera has a foot structure which is iambic and weight sensitive, and that the foot has an important role to play in the domains of vowel harmony and tone spreading. In this chapter, we will consider the evidence for the foot in Kera. In most languages, any discussion of the foot structure will focus on the positioning of stress in the language. However, I cannot use stress as an indicator of the structure, because overt stress does not play a major role in the Kera system.

There are three main areas where we can look for the evidence of iambicity: Firstly, we need to establish that Kera shows quantity contrasts. This is very clear, with a number of minimal pairs, plus anecdotal evidence that literacy classes only became successful for the Kera when length was marked in the orthography. The second pointer is that there is a connection between quantity and tones and between quantity and vowel allophones. This I will also establish, although detailed discussion will be deferred to chapters 3 and 4. The third area of the evidence (and the one which I will concentrate on in this chapter) is the data which shows that there are structural changes occurring because of the foot structure.

This chapter argues that feet in Kera are constructed over a combination of light and heavy syllables, and that lengthening of the vowel takes place as necessary to form the iambic feet which are heavy (-) or light-heavy (∪ -). Parsing in Kera takes place at lexical word level, with adjustments made at phrase level. With the help of data taken mainly from a Kera folk tale, we will consider three strategies which are employed to avoid unfooted elements within the phonological phrase and to ensure that the feet are well formed. These strategies are, in order of preference: combining a syllable with the following syllable to make a new foot, deleting a vowel, and lengthening a vowel. This will be demonstrated with words that surface as [CVC] mid-phrase and [CVCV:] in phrase-final position. I will argue that the only underlying form which can give these two surface forms is /CVCV/. We will see that short vowels in head position are lengthened in order to give the head of the foot more weight. This lengthening, which typically takes place over a ∪ ∪ sequence in phrase final position, forms a (∪ -) foot. In addition, in non-head vowels, we will see that some phonetic shortening effects take place in order to maximize the contrast between the two syllables in iambs. We will also consider how at the right edge of the phonological phrase Kera allows for the possibility of an unfooted light syllable, which I will call a 'stray syllable'. The treatment of such extrametrical syllables has been described in detail by Kiparsky (1991) and I will adopt a similar approach. We will note that non-footed light syllables at the right edge of the phonological phrase exhibit no lengthening. Although a ∪

∪ sequence is generally avoided, epenthetic vowels and multiple function words may cause this sequence to surface as they cannot be lengthened. This rare emergence of the ∪ ∪ sequence can be accounted for by the appropriate ranking of constraints using an Optimality Theory framework.

Before discussing the evidence for the existence of feet in Kera, we need to remind ourselves of certain facts about the syllable structure and the vowel system.

2.1.1 Basic facts

Kera syllables can be light or heavy. There is no phonetic difference between long VV and lengthened V: vowels, so the use of the VV or V: notation is simply a question of analysis and is not meant to represent any measurable difference in duration. However, the difference between short and long vowels in clearly measurable.

(1) *Kera syllable structure*

Light syllables:	(C)V	bàaŋà	'elephant'
Heavy syllables:	(C)V: (vowel lengthened)	/cáwá/→cɔ́wá:	'fire'
	(C)VV (lexically long vowel)	bàaŋà	'elephant'
	(C)VC	kān	'water'

Kera has six vowels as follows:

(2)

i ɨ u

ɛ ɔ

a

Each vowel can be long, with the same set of features as short vowels (in terms of [back], [round] and [high]). There are no diphthongs. The three non-high vowels have alternants: ɛ/e, a/ə, ɔ/o.[1] In each case, the second vowel differs from the first by introducing the feature [+ATR]. The [+ATR] vowel is found in certain CV syllables only, and these syllables are always followed by a heavy syllable. In all other situations, the [-ATR] vowel is selected.

[1] Either of the two alternates could have been chosen to represent the three lower vowels, but I have chosen [ ], a, ɔ because these three vowels surface in the majority of environments and are found in head vowels.

I will claim that these CV syllables with the [+ATR] feature are non-head syllables. Head syllables are heavy in one of two ways; Either there is a coda, or the vowel is long and bimoraic, giving the structures CVC or CVV. So possible feet are:

(3)	Light heavy (∪ -):	(CV.CVV) or (CV.CVC)
	Heavy (-):	(CVC), (CVV)[2]

Syllables are parsed left to right according to their weight and position within the word. Any non-footed 'stray' syllables are generally located at the right edge of the phrase.

The evidence for foot structure gains strong support from the choice of alternates among the non-high vowels in certain positions in the word. Non-heads within a foot will choose [e, ə, o] rather than [ɛ, a, ɔ]. Heads will always choose [ɛ, a, ɔ]. So, for example, feet containing the /a/ vowel will be of the following structure:

(4)	Feet containing /a/ vowel	Light heavy (∪ -):	(Cə.Caa) or (Cə.CaC)
		Heavy (-):	(CaC), (Caa)

One of the main pieces of evidence for the foot in Kera is that /CVCV/ words do not surface as a CVCV string of segments. Either the final vowel is deleted so that a (CVC) foot is formed, or the final vowel is lengthened forming a (CVCV:) foot. We will look at the conditions that give rise to each of these cases in the following section.

The structure of this chapter is as follows: In §2.2, we will discuss the main evidence for the foot covering the following points: (i) changes in /CVCV/ words which sometimes undergo lengthening and sometimes deletion of the final vowel, (ii) the duration of vowels indicating headship, (iii) the vowel quality in the allophones also indicating headship, (iv) the intensity of heads and non-heads, (v) the vowel harmony domains, (vi) the tone spreading domains, (vii) the perception of weight and foot structure by Kera speakers, (viii) syllabic nasals, and (ix) issues of binarity, function words, epenthetic vowels and the possibility of a ternary structure. §2.3 covers the analysis of the Kera foot in an OT framework. §2.4 considers the special case of the obstruent release and discusses how words containing these releases add more support to the case for the iambic foot in Kera.

[2] Throughout this chapter the notation V: will be used for a lengthened vowel and VV will be used for a long vowel (which may or may not have been lengthened). As there is no way of telling these apart empirically, the VV notation will be used throughout the OT section. But elsewhere V: is used where it is helpful to emphasize the fact that lengthening has taken place according to the analysis.

§2.5 looks in more detail at the question of whether the vowel allophones should be categorized as phonological entities or as undershoot.

2.2. Foot structure and arguments for a foot

2.2.1 Deletion and lengthening of vowels in /CVCV/ words

My initial hypothesis is that Kera has only (-) and (∪ -) feet, since surface ∪ ∪ sequences do not exist except in series of epenthetic vowels or possibly function words (see §2.2.8). Hayes (1995, 1981) formulated the Iambic/Trochaic Law as a response to languages which show a preference for heavy syllables at the right edge of the foot. In iambic systems, (∪ -) is the preferred option and (∪ ∪) is the least preferred, because (∪ -) accentuates the contrast between the two syllables. Hayes would expect to find lengthening in the heads of iambs to emphasize the contrast in weight. Elements contrasting in intensity naturally form groupings with initial prominence, i.e. trochaic, whereas elements contrasting in duration naturally form groupings with final prominence, i.e. iambic. As a contrast in duration is the focus of an iamb, this is best achieved with a second syllable having a duration of at least two morae. Kera follows this preference. (∪ -) is the most preferred, then (-), and (∪ ∪) is avoided by lengthening or deletion.

Iambic lengthening is common in many languages. For example in Choctaw, the vowels which are lengthened are governed by the position in the foot.

(5) *Choctaw (Hayes 1995)*

/litiha-tok/ → (liti:)(hatok)	'it was dirty'
/sa-litiha-tok/ → (sali:)(tiha:)(tok)	'I was dirty'

Other similar examples not shown here include Kashaya (Buckley 1998) and Hixkaryana (Derbyshire 1979). A few languages, including Central Alaskan Yupik (Baković 1996, Blevins 1995, Hayes 1995) can also achieve an iambic foot by lengthening a consonant rather than a vowel:

(6) $(CVCV)C_1V \rightarrow (CVCVC_1)C_1V$

Slovak has yet another strategy for achieving a well formed iambic foot: Instead of the second syllable lengthening, the first syllable is shortened (Bethin 1998, Mellander 2000, Mellander 2001).

Most linguists explain iambic lengthening in terms of the speakers' goal of achieving maximum contrast between head and non-head syllables. Iambic lengthening is a

good diagnostic for the existence of iambs (Hayes 1985, 1987, 1995, McCarthy and Prince 1986). Hayes (1999) notes that languages with a syllable weight distinction typically also have a vowel length distinction and an iambic foot system (Hayes 1987, Kager 1995a, McCarthy and Prince 1999a).

Few languages use both lengthening and deletion, particularly not on the same underlying structure, but Ibidio (Akinlabi and Urua 1992; Olanike-Ola 1997) comes close. For negated verbs, /CV/ is lengthened to [CVV], /CVVC/ is shortened to [CVC], while /CVC/ remains unchanged.

(7) *Ibidio (Akinlabi and Urua 1992; Olanike-Ola 1997*

dá	'stand'	dáá-ɣa 'not standing'
kɔ́ɔŋ	'hang on hook'	kɔ́ŋ-ŋɔ́ 'remove from hook'
kóp	'hear'	kòp-pó 'not hearing'

In Kera we have both iambic lengthening, and contrastive vowel length, and an alternative strategy of vowel deletion. /CVCV/ words have two possible outputs, either [CVC] or [CVCV:], but not *[CVCV]. The examples below show how this applies to the noun /bègɛ́/ and the verb /hámɛ́/:

(8)	.....<u>bɛgɛ</u> nuutuŋ → (bèg)(núu)(túŋ)	'his animals'	.....<u>bɛgɛ</u> → (bègɛ́:)	'animals'
(9)	.....<u>hamɛ</u> baaŋa → (hám)(bàa)ŋà	'eat an elephant'	.....<u>hamɛ</u> → (hámɛ́:)	'eat'

For both of the outputs [CVC] and [CVCV:] to be generated from the same underlying representation, that UR must be /CVCV/. A /CVC/ input could not explain the lengthened vowel as (CVC) is a well-formed foot. Likewise, with /CVCVV/, there would be no reason to delete the final long vowel as (CVCVV) is a well-formed foot. The only underlying form that can give both [CVC] and [CVCV:] as outputs is /CVCV/. Further evidence for this underlying form comes from the duration of the vowels when the definite article [-ŋ] is added. In this case there is no phonological lengthening in the output, and the second vowel has a duration of approximately 60 ms.

(10)	For an input of /CVCV/:	With definite article, [-ŋ]: no change (CVCVŋ)
		Phrase medial: final vowel deletion (CVC)
		Phrase final: 2nd vowel lengthened (CVCV:)

(11) Input /bɛgɛ/

Definite article:	[(bègɛ́ŋ)]	*animal-DEF*	'the animals'
Phrase-medial:	[(bɛ̀g) (núu)tú]	*animal his*	'his animals'
Phrase-final:	[(bègɛ́:)]	*animal*	'animals'

This pattern applies to all words with the underlying form /CVCV/. In Pearce (2007a) there are further examples where vowels appear to have been deleted from the Proto-Chadic form, as proposed by Stolbova (1996). In each example in (12), the addition of a prefix causes the deletion of the underlined vowel. If that vowel remained, the surface form would include a (CVCV) foot. The fact that it is deleted supports the claim that (CVCV) feet are not permitted.

(12)	UR	SR	Unattested form
/paka/ 'bowl'			
Singular:	/páká/	[(pɔ́ká:)]	*[(paka)]
With plural K- (-w):	/K-pa̱ká-w/	[(káp)(káw)]	*[(kapa)(kaw)]
Proto-Chadic: *lVgV 'skin'			
With masculine K-:	/K-lɔ̰gɔ̀/	[(gɔ̀l)(gɔ̀:)]	*[(gɔlɔ)(gɔ:)]
Proto-Chadic: *rVmV 'child/son of/daughter of'			
With masculine K-:	/K-rɔ̰mɨ̄/	[(kɔ̄r)(mɨ̄:)]	*[(kɔrɔ)(mɨ:)]
With feminine T-:	/T-rɨ̰nɨ̄/	[(ɨ̄r)(nɨ̄:)]	*[(tɨrɨ)(nɨ:)]

Inputs other than /CVCV/ never give an output of [CVCV], so we only need to consider what happens when the input includes a /CVCV/ string. The following chart demonstrates that in longer words, the output still does not include a [CVCV] string.

(13) *Feet are (-) or (∪ -) regardless of input*

Input		Output		
a. ∪ ∪	(C)VCV	(-)	(CVC)	phrase-medial
		(∪ -)	(CvCV:)	phrase-final
b. - ∪ ∪	(C)VCCVCV (C)VVCVCV	(-)(-)	(CVC)(CVC) (CVV)(CVC)	phrase-medial
		(-)(∪ -)	(CVC)(CvCV:) (CVV)(CvCV:)	phrase-final
c. ∪ ∪ -	(C)VCVCVC (C)VCVCVV	(∪ -)(-)	(CvCV:)(CVC)[3] (CvCV:)(CVV)	
		or (-)(-)	(CVC)(CVC) (CVC)(CV:)	

∪ represents a light syllable, - represents a heavy syllable.

v represents a non-head, +ATR vowel.

VV represents a vowel which is lexically long, a -ATR head vowel,

V: represents a short vowel which has been lengthened, also a -ATR head vowel

The information above is only convincing if I have empirical measurements to demonstrate the differences in duration (see §2.2.2 for further discussion). Under the current proposal, /∪ -/ words merge on the surface with /∪ ∪/ words phrase finally, both giving (∪ -) feet. My aim therefore is to show that there are no (∪ ∪) feet in the output, and that /∪ ∪/ words surface as (-) or (∪ -). Kera has a vowel length contrast so underlyingly /∪ -/ words do exist. To prove the hypothesis that no (∪ ∪) feet exist, we must consider all situations where (∪ ∪) feet might surface.

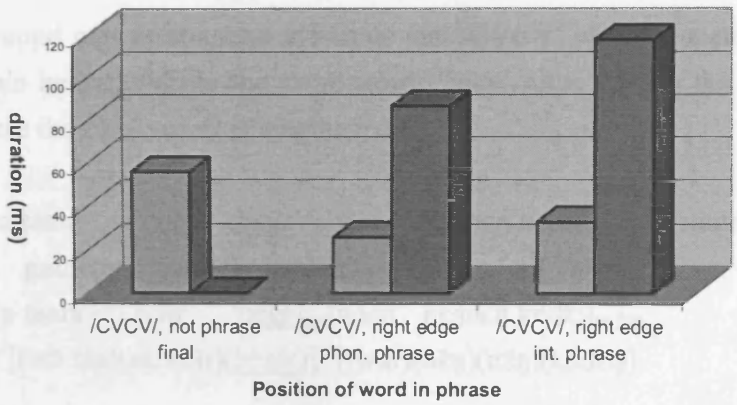
The following graphs give results from a measurement of 55 words collected from a folk story which I claim have the structure /CVCV/. If the hypothesis is correct, there should be no contrast in the duration of the final syllable, and it should always be long or deleted. If any are short, we have a (∪ ∪) foot. However, if all of them are long, we have our first indication of possible iambic lengthening.

Of the 55 words, 34 were not in phrase-final position, 18 were in final position in an XP and 3 were in utterance-final position. We are particularly interested in the non-

[3] We cannot tell the underlying form for these words, but as there are no cases of [CVCV] in the output, we can deduce that the underlying forms which are shown would surface with one or other of these patterns. The cases in a. and b. can be tested in different positions in the phrase. There are few CV prefixes attached to a CVCVC root to prove (13c). Note however the example of /paka/ in (12). This suggests that the second alternative in (13c.) is attested.

utterance-final words as they have no utterance-final lengthening. In (14), the first column indicates the first syllable, and the second column, the second syllable. Observe that in the first case which is in phrase-medial position, the second vowel is deleted. But in the second case, which is in phrase-final position, the second vowel is considerably longer than the first.

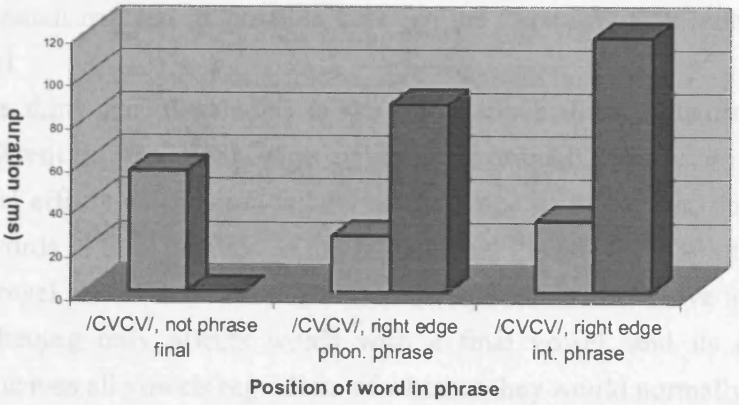
(14) *First and second vowel duration in /CV$_1$CV$_2$/ words*



The first column is V_1 and the second column is V_2 in each case.

It might be argued that the involvement of allophones could be affecting the duration. The following graph therefore shows only the data which contain /i/ and /u/ vowels as these vowels do not have alternate forms. Any differences are therefore quantity, and not quality based. The graph gives much the same results.

(15) *First and second vowel duration in /CiCi/ and /CuCu/ words*



The first column is V_1 and the second column is V_2 in each case.

The first pair of columns shows us that /CVCV/ words which are not in final position in a phonological phrase are realized as [CVC]. The example below shows the word /bɛgɛ/ in phrase-medial position with the deletion of the final vowel.

(16) /wə taara cɨɨr bɛgɛ nuutuŋ/ 'He gathered his animals'
he gathered heads animals his
[wə taara [cɨɨr bɛgɛ nuutuŋ]$_{NP}$]$_{VP}$
→ [(wə̄ táa)(rá:)(cɨ́r)(bɛ̀g)(núu)(túŋ)]

But the second pair of columns shows us that /CVCV/ words can surface as [CVCV:]. In the example below, we see the same word, /bɛgɛ/, appearing at the right edge of a noun phrase. Here the final vowel is lengthened.

(17) /wə taara cɨɨr bɛgɛ wəra neŋneŋ kɛɗɛ/ 'He gathered all the animals'
he gathered heads animals done all all
[wə taara [cɨɨr bɛgɛ]$_{NP}$[wara nɛŋnɛŋ kɛɗɛ:]$_{PP}$]$_{VP}$
→ [(wə̄ táa)(rá:)(cɨ́r)(bɛ̀gɛ́:)] [(wā̄r)(nɛ̄ŋ)(nɛ̄ŋ)(kɛ̄ɗɛ̄:)]

These examples show that /bɛg/ could not be the underlying form of [bɛ̀gɛ́:] as there would never be any reason to introduce a lengthened [ɛ].

When the vowel is lengthened in the (CVCV:) foot it has a duration of approximately 90 ms. The second vowel has more than twice the duration of the first (approximately 30 ms). It becomes the head of the foot, and the lengthening effect on the second vowel is best described in terms of an additional mora being added to the second syllable. In these words, the first vowel is shorter than non-lengthened vowels in other contexts. This is due to a phonetic effect that is found in disyllabic iambs. The speaker makes as much contrast as possible between the duration of the non-head vowel and the head vowel.

The third pair of columns in the graph above show us that the vowel duration is again different at the right edge of an Intonational Phrase. A detailed analysis of intonational effects on duration is beyond the scope of this thesis, but we can note that in /CVCV/ words in final position in the Intonational Phrase, there is a further lengthening of the final vowel in addition to the increase in weight described above for phrase final words. The lengthening only affects words with a final vowel, and its effect appears to be consistent across all vowels regardless of whether they would normally be footed or not.

(18) *Duration of vowels in /CVCV/ words depending on position in phrase*

/CV_1CV_2/	V_1	V_2
non-phrase final	V_1 standard duration (μ)	V_2 deleted (Ø)
phrase-final	V_1 shortened (μ)	V_2 lengthened (μμ)
Int. phrase-final	V_1 shortened (μ)	V_2 super-lengthened (μμ)

The main conclusion to draw from these results is that for words with a /CVCV/ input, the [CVCV] output does not exist. Kera uses either deletion, to form one heavy foot (CVC), or final vowel lengthening so that the word becomes (∪ -), i.e. (CVCV:). In this case the first vowel reduces in quality and duration as it becomes a non-head vowel. Conceivably the first vowel could be lengthened, giving the footing (CV:)CV, but this form would never win over (CVCV:) because in (CV:)CV, a syllable is left unfooted unless joined to the next word. Therefore, the output forms for /CVCV/ are (CVC) and (CVCV:).

(19) *Lengthening and shortening effects*

Input	/CVCV/ not phrase edge	/CVCV/ phrase edge	/CVCV/ inton. phrase edge
Output	(CVC)	(CvCV:)	(CvCV::)

Notation	**Approximate duration**
v is a non-head (+ATR) vowel.	30 ms (1 mora, phonetic shortening).
V is a head vowel in a closed syllable.	60 ms (1 mora).
V: is a lengthened head vowel.	90 ms (2 morae).
V:: is a super-lengthened head vowel.	110 ms (2 morae, phonetic lengthening).

Broselow et al (1997) predict that in languages where CVC is considered heavy, long vowels should be about twice the length of short vowels. The reasoning for this is that as the final C in CVC is assigned a mora in its own right, it does not share a part of the mora associated with the vowel. So a non-lengthened vowel has the duration of one mora, and the lengthened vowel has the duration of two morae. The results above are close to this prediction, where the duration of one mora is approximately 40 ms and the duration of two morae is approximately 95 ms.

Hubbard (1995a,b) observes that although the phonetic realization of morae is different in every language, we would expect two morae to have longer duration than one in a systematic way. She notes the ratio of short to long vowels in certain languages. For example:

(20) *Ratio of short to long vowels in a selection of languages (Hubbard 1995a,b)*

	short	long
Ciyao	1	2.2
Kikerewe	1	1.8
Luganda	1	3.2
Runyamba	1	1.9

The ratio for Kera appears to be 1:2.4 which is well within the range of these other examples.

The phonetic lengthening and shortening that we have observed in Kera provides strong evidence for the foot. We have seen that syllables in a CV.CVC string shorten and lengthen respectively (with approximate vowel durations of 30 ms : 70 ms), while syllables in a CVC.CV string have no change in the expected duration (with approximate vowel durations of 50 ms : 50 ms as neither of these syllables has any reason to be lengthened or shortened). If there was no iambic foot, the short and long syllables would have the same duration regardless of the order. The next example shows the changes in duration when identical underlying syllables are reversed in order:

(21) /lam.ba/ lə̰mbə̰̀ 'tax' vs /ba.lam/ bə̀lə̰̀m 'love you'
Durations (ms): 63 55 26 73

So the lack of surface [CVCV] forms in lexical words and the changes in the duration of vowels depending on their position gives us strong evidence for claiming the existence of feet in Kera.

2.2.1.1 Other words which could contain (CVCV)

We still need to look at words that might have the underlying form /CVCVCV(C)/ and which have no lengthened vowels. In Pearce (2005a, 2007a), I argued that these words are underlyingly /CVC.CV(C)/. I showed that the transition between the two middle consonants is too short to be considered a vowel and that it should be considered to be a phonetic transition rather than a phonological segment. If this were not the case, and if the footing were left to right, these words would contain a (◡ ◡) foot because the only way to parse [CVCVCV(C)] into admissible Kera feet is to posit a word-initial (CVCV) foot. So if we find true vowels between the two middle consonants in words such as these, then we must conclude that Kera has (CVCV) feet.

Kera has both epenthetic vowels and transitions. The difference between them is shown here.

(22) *Observed differences between epenthetic vowels and transitions*

Epenthetic vowel	**Transition**
Between any two consonants	Not present between sonorants (Hall 2004)
Duration not affected by contiguous consonants	Duration depends on contiguous consonants
Duration approx 30ms	Duration < 20ms

(23) *Differences in analysis between epenthetic vowels and transitions*

Epenthetic vowel	**Transition**
1 mora of weight	No weight
Part of the metrical system	Not part of the metrical system
Cannot be lengthened as a head	Not part of foot structure
Phonological	Phonetic[4]
Introduced to make well-formed syllables when a suffix is added	Introduced between consonants for articulatory reasons

Unlike epenthetic vowels, transitions are not included in the phonology of Kera. They are better considered as a phonetic by-product when certain consonants are pronounced in sequence.

To test for this, the transitions in 85 /CVC.CVC/ words were measured for duration and compared with the underlined vowel in (C<u>V</u>CVC) feet in words of the form: (C<u>V</u>CVC)CV or (CVC)(C<u>V</u>CVC). In words of these forms, the status of the underlined vowel is not in question, but the duration of the vowel is the shortest that can be found in Kera and it therefore makes a good comparison with the transitions. In all of the words compared, the questionable vowels, which I claim to be transitions, all had a duration of less than 20 ms, whereas all of the other vowels (including the underlined vowels in the (C<u>V</u>CVC)CV or (CVC)(C<u>V</u>CVC) words) had a duration of more than 30 ms. This suggests that the hypothesis concerning transitions is probably correct, but this was verified further by comparing the ratio of the duration of the vowel or transition with the duration of the following vowel. In feet, this ratio stays reasonably constant, and if the transitions are in

[4] This division is supported by Warner et al (2001) who suggest that in general when epenthesis brings structure closer to a CV pattern and is not limited to slow speech it is likely to be phonological while transitions involve phonetic adjustments to the timing of existing gestures only.

fact vowels in the non-head position in a foot, then they should give the same ratio[5]. The ratio was calculated as follows:

(24) In (C<u>V</u>CVC)CV and (CVC)(C<u>V</u>CVC) words:

$$\text{Vowel ratio} = \frac{\text{underlined vowel length (ms)}}{\text{final vowel length (ms)}} \qquad \text{(Range: 0.4-0.8)}$$

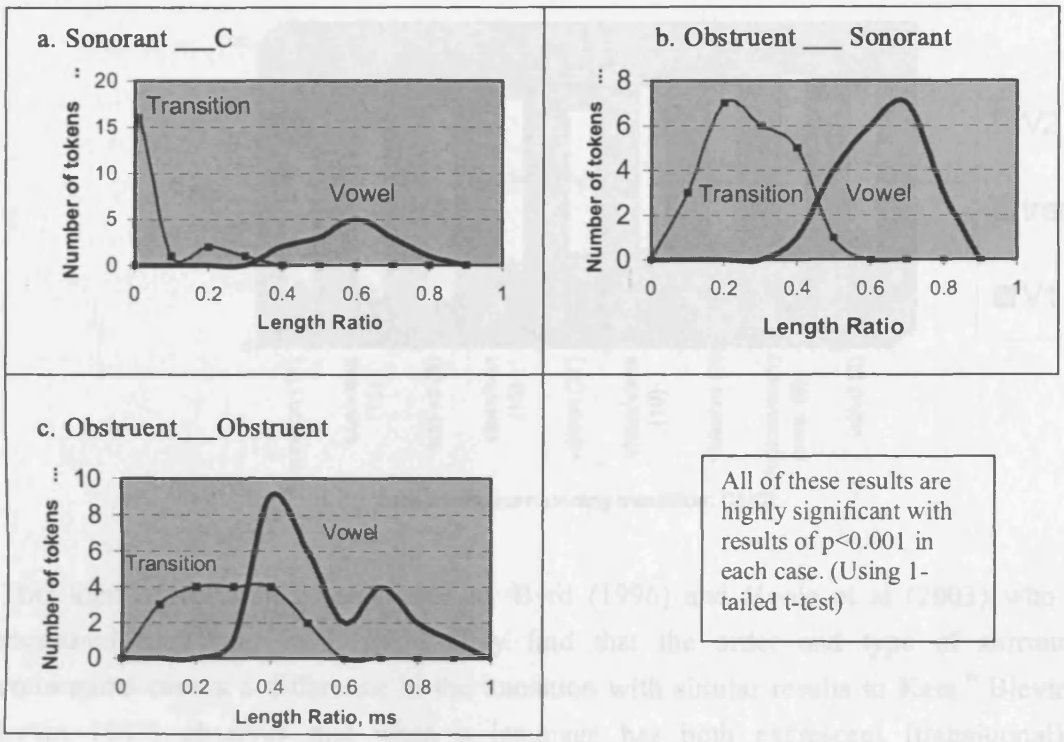
In [CVC....CVC] words (where the dots represent the transition or vowel being tested):

$$\text{Transition ratio} = \frac{\text{transition length (ms)}}{\text{final vowel length(ms)}} \qquad \text{(Range: 0-0.4)}$$

The ranges indicate that there was a clear difference between the vowel and the transition. The graphs below split these results up into categories depending on the type of consonant just before the transition/vowel in question. (25a.) shows the results where the preceding consonant is a nasal, so (N<u>V</u>CVC)CV and (CVC)(N<u>V</u>CVC) words are compared with CVN...CVC words. The ratio for the transition has a mean lower than 0.1 while the vowel insertion has a mean of 0.6. In this case it is clear that the transitions are not vowels. In (25b.), the same comparison is made but with obstruents preceding and a sonorant following. Although the ratios are closer to each other here, they are still significantly different (with $p<0.001$). In (25c.), with obstruents on either side of the transition or vowel, the results are more similar, but the differences are still highly significant (with $p<0.001$).

[5] The possibility of the transitions being heads was not considered as the durations are too short for this to be viable.

(25) *Comparison of transitions and vowels (using ratio compared with following vowel) (Pearce 2007a)*

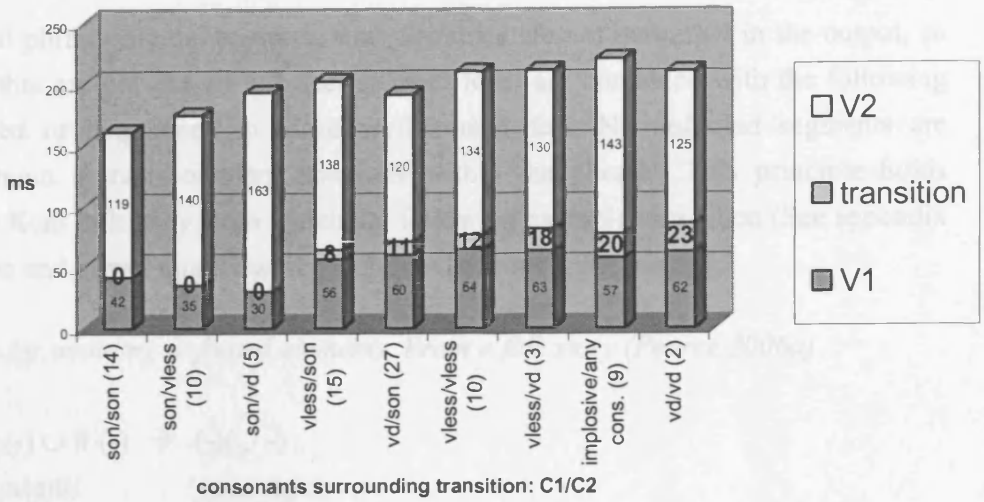


In none of these diagrams could we reasonably claim that the transitions are in fact vowels. The fact that the ratio changes for the transitions depending on the nature of the surrounding consonants is further evidence that we are dealing with transitions. I would expect the duration of true vowels to be reasonably unaffected by the surrounding segments, but transitions by their very nature are highly affected by the surrounding consonants. We can therefore conclude that in the 85 /CVC.CVC/ words tested, that there is a transition between the two middle consonants and not a vowel.

So not only have I shown that /CVCV/ words do not surface as [CVCV], but also, we have seen that longer words with [CVCV] strings contained in them do not seem to exist either. The surface forms [CVCV] and [CVCVCVC] do not exist in Kera. The simplest conclusion is that this is because the (CVCV) foot is not permitted in Kera. Underlyingly, these sequences can exist, but the Kera speaker employs some strategy so that the surface form does not contain the unacceptable (CVCV) foot.

We can investigate the effect of surrounding consonants on transitions further. The variation in transition duration is shown in (26) measured over 98 words.

(26) *Duration of transition in CVC_LC_2V: and CVC_LC_2VC words*



This kind of variation is supported by Byrd (1996) and Hoole et al (2003) who have measured transitions in English. They find that the order and type of surrounding consonants causes a difference in the transition with similar results to Kera.[6] Blevins (in Levin 1987) observes that when a language has both excrescent (transitional) and epenthetic vowels, excrescent vowels are not counted in the metrical system whereas epenthetic vowels are. In Piro (Matteson 1965), transitions are inserted following [-son] consonants. This is basically the case for Kera. In some languages, these become part of the phonological system, but in Kera, they are best considered as phonetic detail outside of the phonological system.

2.2.1.2 Stray syllables

I have concentrated in this section on the need for Kera to avoid a (CVCV) foot, but where possible, unfooted syllables are also avoided. In this section we will see that this is done by combining syllables in a foot, deleting segments and lengthening.

At the word level parse, a CV syllable at the right edge may be left unfooted. These 'stray' syllables arise when a CV syllable follows a heavy syllable and when there are no syllables to the right of the word to be parsed in the same phrase.

[6] The perception of the presence of a vowel also differs between languages. Dupoux et al (1999) have tested Japanese and French speakers with nonsense words of the form VCuCV, with varying durations for the [u] vowel. The Japanese heard the [u] vowel even when there was no [u] vowel there, whereas for the French, the cut off point was 38 ms. This shows that a measure of duration alone is not enough to decide on the phonological status of a transition.

(27) *Word structure with unfooted syllables at the right edge*

(bàa)ŋà 'elephant' (gə̀dàa)mɔ́ 'horse'

In phonological phrase-internal position, stray syllables are not permitted in the output, so any segments that are not parsed into feet at word level are combined with the following syllable, deleted or lengthened to make well-formed feet. No unfooted segments are allowed to remain in non-boundary positions within the phrase[7]. This principle holds throughout the Kera folk story from which the following examples are taken (See appendix 4). The duration and vowel quality were taken into account in the parsing.

(28) *Strategies for avoiding unfooted elements. From a folk story (Pearce 2006a)*

a. *Combining* (-) ∪ # (-) → (-)(∪ -)

/saama nɨmti/ 'your rope'

rope yours

word level (saa)ma (nɨm)ti

phrase level (sāa)(mə̄nɨ̄m)tí

In this case the <u>ma</u> combines with the next foot.

b. *Combining* (-) ∪ # (∪)# → (-) (∪ -)

/baaŋa mɔ/ 'Is it an elephant?'

elephant question

word level (baa)ŋa (mɔ)

phrase level (bàa)(ŋə̀mɔ́:)

The <u>ŋa</u> combines with the following syllable which is lengthened.

In example (28a), the [ma] syllable is unfooted at word level, but combines with the next foot so that it is footed at the phrase level. In chapter 3 we will see how this phrase level footing does not mean that the vowel will harmonise with vowels in the next word. The vowel harmony domains are restricted to word level. But in terms of duration and non-head quality, the vowel is footed with the first syllable of the following word. The [ti] syllable in (28a) will remain unfooted if another phrase follows the noun phrase in the example, or it will be lengthened and form a foot if it is utterance final. In (28b), the [ŋa] syllable combines with the following heavy syllable to form one disyllabic foot.

The next strategy is deletion:

[7] With the exception of a series of function words or a series of epenthetic vowels. See § 2.2.8.

c. *Deletion* (∪ ∪)# (-) → (-)(-)

/bɛgɛ nuutu/ 'His animals'

animal his

Word level (bɛgɛ) (nuu)tu

phrase level (bèg)(núu)tú

The /ɛ/ is deleted here as the rest of the word then forms a foot. Deletion is preferred to lengthening as a strategy for making well-formed feet where possible. (Note that in a. and b., deletion would not have helped.)

d. *Deletion* (∪ ∪)# (∪ -) → (-)(∪ -)

/ŋɛmɛ hulum/ 'choose a man'

choose man

Word level (ŋɛmɛ) (hulum)

phrase level (ŋém)(hùlùm)

As in (28c), /ɛ/ is deleted.

In both of these cases, the existence of the /ɛ/ could be deduced from the fact that in phrase-final position, it would be lengthened rather than deleted and because when a definite article -ŋ is added, the short vowel is retained.

e. *Lengthening* (-) ∪# (∪ ∪) → (-)(-) (∪ -)

/kuuri kaya/ 'their necks there'

their-neck there

Word level (kuu)ri (kaya)

phrase level (kúu)(rí:)(kə́yá:)

The /ri/ lengthens here. Note that the parsing is not *(-)(∪ -) ∪, which is what phrase level parsing would predict. This shows that parsing takes place at word level and is then adjusted at phrase level.

f. *Lengthening* (-) ∪# (∪ -) → (-)(-) (∪ -)

/gulnu cawaŋ/ 'saw the sun through it'

looked-it the-sun

Word level (gul)nu (cawaŋ)

phrase level (gùl)(nù:)(cə́wáŋ)

The /nu/ syllable cannot join the next foot which already has two syllables, and nothing is gained if the [u] deletes, so the best option is to lengthen the [u] to make a well-formed heavy foot.

So Kera uses three strategies to form acceptable feet at phrase level. (i) A light syllable is combined with a following syllable to make a (∪ -) foot. (ii) (∪ ∪) feet become (-) feet in phrase internal position as the final vowel is deleted. (iii) A light syllable following a heavy foot cannot delete. If it cannot combine with the following word, then the vowel will lengthen to form a heavy syllable.

In phrase-final position (when not utterance-final), unfooted material is permitted. But unfooted light syllables ('stray syllables') do not undergo any lengthening. (See chapter 3 for more discussion). The only light syllables that get lengthened in phrase final position are head vowels in a (CvCV:)] foot. In the following two examples, the underlined syllable is not lengthened. In each case the syllable is at the right edge of a phonological phrase, which is aligned with the right edge of an XP.

(29) /tɔ jii tiniini dɨ gɔrnɔy/
he does trick with hyena
[to jii [tiniini]$_{NP}$ [dɨ [gɔrnɔy] $_{NP}$]$_{PP}$]$_{VP}$
[(tó jii) (tínii)nî] [(dɨ̌ gɔ̀r)(nɔ̀y)] duration of i in -ni is 43 ms[8]
'he does a trick on hyena'

/wɨ kaa saama kuur bɛgɛ-ŋa/
he throws rope neck of animal-the
[wɨ kaa[saama]$_{NP}$ [kur [bɛgŋa] $_{NP}$]$_{PP}$]$_{VP}$
[(wɨ́ káa)(sāa)mā] [(kūr)(bɛ̀g)ŋà] duration of a in -ma is 46 ms
'he throws a rope (round) the neck of the animal'

As stated above, /CVCV/ sequences at the right edge of a phrase undergo lengthening. The lengthening is motivated by the foot structure, not by the phrase boundary. However, the phrase boundary does affect the choice of repair strategy, which is lengthening rather than deletion. See the lengthening of the final vowel in /saamaŋa/:

(30) /saamaŋa kuur giwgiw/ 'the rope is round the neck of the bat'
rope-the-(LOC.) neck bat
[(sāa) (mə̄ŋā:)]$_{NP}$ [(kūr)(gǐw)(gǐw)]$_{PP}$ duration of [a] is 84 ms

In summary, in phrase final position, a ∪ syllable is permitted to remain unfooted, but a sequence of ∪ ∪ must be footed, and therefore undergoes lengthening of the final vowel to

[8] Compared to a typical lengthened vowel of 88ms.

form a (∪ -) foot. We have not seen any examples of a ∪ ∪ sequence in the output, even in phrase final position. This gives support to our main hypothesis that ∪ ∪ sequences are altered to form a (∪ -) foot. We have seen that parsing into feet takes place at phrase level and is exhaustive except at the right edge of the phrase or over a series of epenthetic vowels or function words. At these points only, single unfooted light syllables are permitted.

Similar patterns are seen in loan word adaptations from French and Arabic. In (31), segments are added at the right edge to make a well-formed syllable, and internally to avoid CC clusters at the syllable margin. In each case the Kera form is made up of heavy or light-heavy feet with an optional stray syllable at the right edge and a vowel release following word final obstruents. In some cases, the correct foot structure is achieved by the insertion of a consonant, so in *frigo*, an [ŋ] is added (presumably as a definite article, but this then became part of the word). Similarly the inserted [r] in the Kera form of *la klɛ* also makes the first foot well-formed.

(31) *loans also conform to iambic foot structure*

la pɔrt >	(lə̄pɔ̄r)té	'door'	
mars >	(mār)sí	'March'	
frigo >	(fɪ̄rī:)(gɔ̀ŋ)	'fridge'	
sãtr afrik >	(sɔ̄n)(tə̄rāf)(ríkī:)	'Central Africa'	
la klɛ >	la kəle (Chadian French) > (lə̄kēr)lé	'key'	*laklɛ: 'key'
kasɛt >	(kā:)(sétī:)	'cassette'	
brik >	(bĭrĭ:)kî	'brick'	

In (32), segments are deleted with the same goal of forming iambic feet.

(32)

French:

la misjɔ̃ >	(lām)(sɔ̄ŋ)	'church'
telefɔn >	(tēl)(fɔ́n)	'telephone'

Arabic/Fula:

nasaara >	(mə̄sār)	'white expatriate'

Fula:

maskore >	(mās)(kɔ̄r)	'millet'
deftere >	(kēf)(tēr)	'book'

In (33) we see lengthening and consonant insertion employed to avoid a (CVCV) foot

(33)	Arabic:	tomatim >	(tōmā:)(tūm)	'tomato'
	French:	prefɛ >	(pērē:)(fɛ́ŋ)	'county chief administrator'
	compare:	suprefɛ >	(sūp)(ré̱fɛ́ŋ)	'chief administrator in sub-county town'

The conclusion for this section is that metrical parsing does take place in Kera and that this explains both the avoidance of a [CVCV] sequence, because a heavy syllable is required for the head, and the strategies for avoiding unfooted syllables because where possible the material is easier to manage when parsed into feet. It is unusual to see a language that employs both deletion and lengthening on the same words, but this can be explained by the insistence on an uninterrupted series of feet in phrase-medial position while retaining the possibility of unfooted syllables at the right edge of the phrase. All of these facts would be very hard to explain without the assumption that Kera has foot structure.

2.2.2 Duration

I have already referred to the lengthening of the second vowel in the /CVCV/ sequence so that a (CVCV:) iambic foot is formed and we have examined the evidence from a number of duration measurements. In this section, we consider other evidence from the duration. As already stated, long and lengthened vowels have the same duration. Silverman (1997) suggests that systems typically maximize the perceptual distinctiveness among their contrastive phasing patterns. This means that if length and lengthening were contrastive, I would expect the difference between them to be clear. In the absence of contrastive patterns or any other evidence, it is safer to assume that length and lengthening are phonologically the same. For this reason, with the exception of /CVCV/ words, it is usually not possible to be certain as to the underlying weight of vowels which appear in the surface form as long. However, if the surface duration of the vowel is relatively short in some conditions, we can conclude that it is short in the underlying form.

In the following example, the two underlined segments demonstrate the difference in duration between two light syllables in the input, one placed in phrase-final position and one placed in intonational phrase-final position. The phrase-final unfooted syllable ma is not lengthened, but all vowels are lengthened in intonation phrase-final position, demonstrated here by na. The duration of the long vowel in [kaa] is provided for comparison with the short vowel in ma.

(34) /wɨ kaa saama kur bɛgŋa/ 'He puts rope round the animals' necks'
he throws rope neck cattle
[wɨ kaa [saama]$_{NP}$ [kur bɛgŋa::]$_{PP}$]$_{VP}$
→ [(wɨ̄káa)(sāa)mā)] [(kúr)(bɛ̀g)(ŋá::)]
Duration (ms): 93 46 182

This example shows that the vowel in a CV syllable will probably be lengthened in utterance final position, but not in phrase final position. In phrase final position the CV syllable is lengthened only if it is preceded by a CV syllable and therefore combines with this syllable to produce a disyllabic foot. This means that the duration of the vowel tells us something about the position of the syllable in the foot and whether it is footed. It also tells us the position in the phrase and the intonational phrase. The following table demonstrates how duration combines with the quality to give supporting cues for headship and the position in the phrase.

(35) *Length, quality, and headedness of vowels in open syllables*

	Head V in foot	Non-head V in foot	Phrase-final non-footed V	Non-footed epenthetic V (in ∪ ∪ sequence)
Head	✓	x	x	x
Footed	✓	✓	x	x
+ATR	x	✓	x	✓
Duration	normal (70ms)	short (30ms)	normal (50ms)	short (30ms)

The only rows that correspond exactly in this table are the last two where -ATR vowels are of a normal duration while +ATR vowels are shorter. This suggests that the ATR quality of the vowel is dependant on the length of the vowel rather than on its position in the foot. Non-head vowels are shorter so that the contrast between non-heads and heads is as great as possible. Epenthetic vowels are also similar in duration to the non-head vowels. These vowels have a +ATR quality in [-high] vowels.

This correlation between length and quality means that the vowels [e, ə, o] are always very short (approx. 30ms), whereas [ɛ, a, ɔ] are longer (>50ms). This same relative contrast in duration is also found in Cantonese (Moira Yip p.c.) although the actual durational values are all longer, and in the Chadic language Sokoro (Gordon Martin p.c.). Some research suggests that this correlation is unusual and that a number of European languages exhibit the reverse correlation, including Dutch, Spanish and English. For these languages it could be suggested that the default position is -ATR and that it takes longer to advance the tongue root for the +ATR vowels. But against this, the work of Gendrot and

Adda-Decker (2005, 2006), which is discussed further in §2.2.3.1, suggests that most European languages do show the pattern of lower vowels being longer with a gradient change in height depending on the duration. They do not classify these vowels into + or – ATR, but their work would suggest that [e] would be short and [ɛ] longer. Further discussion on the ATR feature in Kera is found in section 2.5, and I will return to the subject of the relationship between quality and duration in chapter three. Clearly the exact duration of the vowel is dependent on a number of factors, but we can see that one of these factors is the position of the syllable within the head or outside of the head. The quality of the vowel is affected by the same factors.

For most of this section I have dealt with approximate values for the duration. More precise values for the means in each category are given in the graph below. Each mean was taken over at least 20 words.

(36) *Duration of vowels according to structure*

vowel		**duration (ms)**
transition	...C-C...	9
non-head, open syllable	v in (CvCVC)	27
	epenthetic v in (CVC)(CvCVC)	29
	v in (CvCV:)	29
non-footed, open syllable	V in CV] phrase-final	49
head, closed syllable	V in (CVC)] phrase-final	52
	V in (CVC) word	60
	first V in (CVC)(CVC)	60
head, disyllabic foot, closed	V in (CvCVC)	70
head, open syllable	VV in (CVV)	86
	V: in (CvCV:)	88
open vowel utterance final	CV:: in Int phrases	110

In the chart above, only vowel lengths were measured, and according to this measure, the stray syllable appears to be somewhat like the head syllable. However the position of the stray syllable becomes less clear if we consider syllable durations. For the next table, the vowel and syllable durations were measured in several words from two folk stories. 14 to 51 measurements were taken in each category, and all results were significant with $p < 0.05$.

(37) *Correlation of duration and vowel quality (Pearce 2005a, 2006a)*

	Non-head or stray		*Heads*		
	non-head	*stray CV*	*head CVC*	*head CVV*	*head CvCV:*
syllable duration (standard deviation)	60.8 ms (17.7)	78.5 ms (12.0)	156.0 ms (25.7)	142.1 ms (32.8)	150.4 ms (24.8)
vowel duration (standard deviation)	30 ms (17.2)	51.5 ms (15.8)	62.0 ms (10.77)	80.0 ms (23.1)	108.0 ms (24.7)
ATR	+	-	-	-	-
Example	(tə̱rá:)	(bàa)ŋà	(tár)	(bàa)ŋà	(tə̱rá:)
No. of tokens	18	12	51	40	14

Comparing the vowel duration of stray syllables, we find as we would expect that they are intermediate between non-heads and heads, but if we compare the syllable duration of CVV head syllables with stray syllables and CV non-heads, we find that by this measurement, the stray syllables are closer to non-heads. Then again, the ATR quality suggests that strays are like heads. So this table leads us to conclude that the strays are not really like either of the categories of head or non-head, but instead something in between. This actually makes sense if we think of the stray as having default values of duration and quality, the head then extends the duration and lowness of the vowel while the non-head diminishes the duration and quality. In discussing this, we are clearly at the interface of phonology and phonetics. Some would be happier categorizing the head, non-head and stray syllables with clear contrasts in features, while others would see this as an example of a phonetic continuum where a target vowel is only fully arrived at with the duration of a long vowel, and all other vowels will miss this target by an amount that depends on the duration of the vowel. This is discussed further in §2.2.3.1.

Despite this discussion, we can still say in general that the duration and ATR facts divide between head and non-head. For this reason, I continue to talk of allophones even though the stray syllables provide some interesting research over the middle ground. From the point of view of the main aim of this chapter, the duration facts point clearly to the existence of the foot.

In other Chadic languages the evidence for the avoidance of [CVCV] patterns isn't very convincing, although it must be said that in many of these languages, careful acoustic measurements are not available. But we can say that weight and duration plays an important role (Roberts 2001; Wolff 2001; Jaggar and Wolff 2002; Newman 1972, 2000). In these languages, quantity distinctions are made and certain syllables are obligatorily heavy. For example, in Hausa plural nouns, the final syllable is always heavy except in

reduplicated forms and tone contours are permitted on all heavy syllables including CVC but not on light syllables (Gordon 2004). In Hedɛ̀, allophonic variation is determined by the weight of the syllable and the foot structure (Vaibra 2003 and Roberts p.c.).

The following table (Pearce 2007a) shows the areas where weight and foot structure are known to play a role in certain Chadic languages. Reference is made to the evidence from quantity, but also from allophonic and tonal cues. We will discuss the allophonic and tonal evidence in Kera in the next sections.

(38) *Quantity and foot structure in Chadic*

	Quantity distinction	Quantity sensitive allophones	Foot structure	Iambic	Quantity affecting tone	Quantity Sensitive feet
Kera	✓	✓	✓	✓	✓	✓
Hausa	✓	✓	✓	✓	✓	✓
Hedɛ̀	✓		✓	✓		✓
Bole	✓		✓			✓
Sokoro	✓	✓				
Migaama	✓				✓	
Gœmai	✓	✓				
Kanakuru	✓				✓	
Bade	✓	✓				
Ngizim	✓	✓				
Mukulu	✓					
Mawa	✓					

2.2.3 Vowel quality

In this section, we look more systematically at the vowel quality differences as shown in the allophones which alternate depending on whether they are in the non-head or head position in the foot. Kera has 6 vowel phonemes as shown in the chart below. Three of the vowels have allophones.

(39) *Allophones in Kera vowels*

Phonemes:	/i/	/ɨ/	/u/	/ɛ/	/a/	/ɔ/
Head (-ATR)	[i]	[ɨ]	[u]	[ɛ]	[a]	[ɔ]
Non-head (+ATR)				[e]	[ə]	[o]

Lexical monosyllabic words always select vowels from the top set: [i] [ɨ] [u] [ɛ] [a] [ɔ]. If as I claim, Kera has feet, then monosyllabic lexical words must be feet, and it follows that they are also heads. This implies that these vowels are head vowels. We can deduce then that the vowels [e] [ə] and [o] are non-head vowels. They are of short duration and never appear in heads or word-finally.

[ɛ] [a] [ɔ] always have a duration greater than 50ms, and are found in head position, as underlined in (CV̲C), (CVCV̲:) and (CVCV̲C). (40) gives examples of these three forms:

(40) *Comparison of head and non-head vowels*

a.	[pɛ́p]	'god'	[gɔ̀l]	'to look'	[tár]	'a run' (not phrase-final)
b.	[pépɛ́:]	'god'	[gòlɛ̀:]	'to look'	[tərá:]	'a run' (phrase-final)
c.	[Pépɛ́ŋ]	'God'	[gòlɔ̀ŋ]	'looked'	[fəlāŋ]	'found'

In contrast to this, [e] [ə] [o], always have a duration of approximately 30ms, and are found only in non-head position. They are never found in monosyllabic words, or word-finally. So the only place in which these vowels are found is in the underlined position in the following feet: (CV̲CV:) and (CV̲CVC).

(41) a.	[pépɛ́:]	'god'	[gòlɛ̀:]	'to look'	[tərá:]	'a run' (phrase-final)
b.	[Pépɛ́ŋ]	'God'	[gòlɔ̀ŋ]	'looked'	[fəlāŋ]	'found'

The above examples suggest that the allophones are chosen according to the position in the foot.

(42) *Vowel quality in heads and non-heads (Pearce 2006a)*

	Non-head	*Head*		
	CV	*CVC*	*CVV*	*CvCV:*
ATR	+	-	-	-
Examples	(pépɛ́:)	(pɛ́p)	(kɛ́ɛ)rɛ́	(pépɛ́:)
	(tərá:)	(tár)	(bàa)ŋà	(tərá:)
	(gòlɛ̀:)	(gɔ̀l)	(gɔ̀ɔ)gɔ̀	(gòlɔ̀ŋ)

In the examples below from Pearce (2007a), the heads in the output are underlined. The choice of allophone is clearly dependant on whether the syllable is the head of a foot or not.

(43) *Kera structures with vowel quality differences in head and non-head*

Input		Output *Heads are underlined*		
∪∪	/pɛ́.pɛ́/	(-) (∪ -) (phrase-final)	(pɛ́p) (pɛ́pɛ́:)	'god'
- # ∪∪	/tɛ̄n gɔ̀lɛ̀/	(-)(-) (-)(∪ -) (phrase-final)	(tɛ̄n)(gɔ̀l) (tɛ̄n)(gɔ̀lɛ̀:)	'I look'

∪ represents light, - represents heavy

Other Chadic languages also show allophonic changes. Hausa has a difference in vowel quality corresponding to length with [i, e, a, o, u] in CVV syllables, but a restriction to [i, a, u] in CV syllables (Newman 1972, 2000, Gordon 2002, Carnochan 1988). Hedɛ (Vaibra 2003) has only high vowels in non-heads within the verb. Verbs with the following CV structure have unrestricted vowels (underlined): (CV), (CVC), (CVC)(CV), (CVC)(CVC). But the first (non-head, not underlined) vowel in the following structures must be a high vowel: (CVCV), (CVCVC). The Chadic languages Sokoro (Gordon Martin p.c.) and Gœmai (Birgit Hellwig p.c.) show that weight affects the choice of vowel between e/ɛ and o/ɔ. In the Sokoro example below, [e] and [o] appear in light syllables, while [ɔ] and [ɛ] are found in heavy syllables.

(44) so.ʔɔl 'guinea fowl' so.ʔo.li 'guinea fowl (pl)'

ke.ne 'here' kɛ:.ne 'ours'

(Syllable boundaries marked with full stop)

Although no other Chadic language appears to have the same force of evidence for feet as Kera, these examples suggest that further investigation about the role of metrical structure in Chadic languages might be profitable.

In summary, the Kera vowel quality facts are that the non-head vowels [e ə o] are found only in non-head position. The head-vowels [ɛ a ɔ] are found elsewhere. Lexically long vowels are always heads as in the first syllable of /baaŋa/ (baa)ŋa 'elephant'. Light syllables within a foot always have a vowel from the set of non-head vowels as in the first syllable of /kabaŋ/ (kəbaŋ) 'tree'. The changes in quality of the vowel add to the evidence for iambic feet in Kera because it would be hard to find any other motivation for these alternations.

2.2.3.1 Undershoot or allophones?

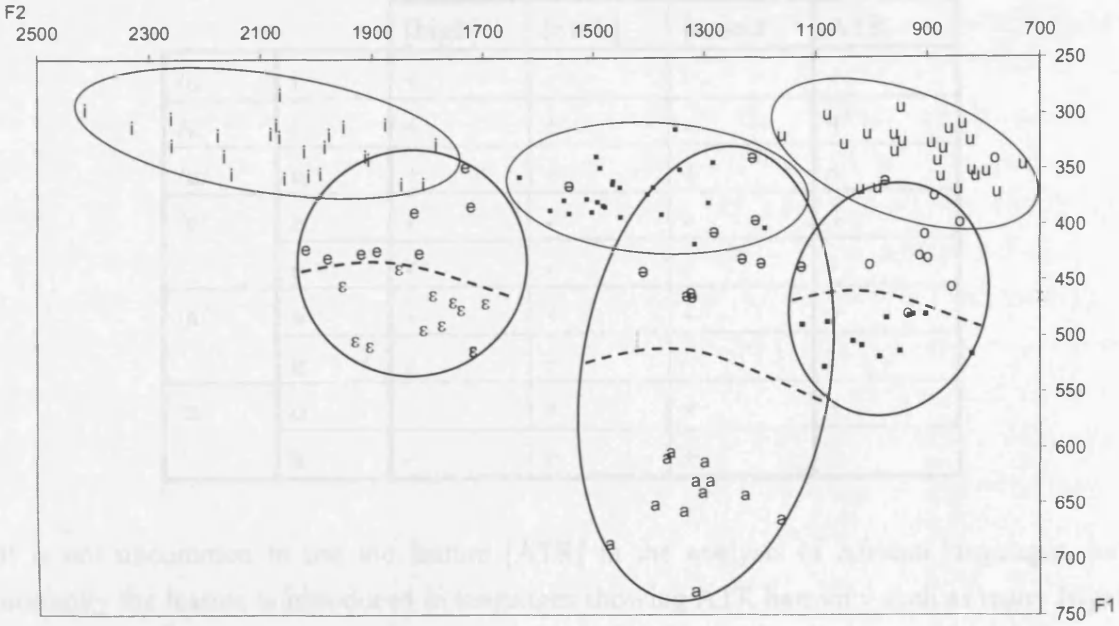
So far I have treated the ATR allophones in non-high vowels as phonological alternations, but when we look carefully at the acoustic measurements of these vowels, the question arises as to whether they really are alternations involving the feature [ATR], or rather, one target vowel with undershoot in non-head vowels due to the lack of sufficient duration to arrive at the target. We have seen how the [+ATR] allophones [e, ə, o] are found only in the non-head position of the foot.

(45) *Examples of allophones*

		non-head	vowel onset	head	stray syllable
/ɛ/	[e] (+ATR)	(fḗlɛ́:) 'to find'			
	[ɛ] (- ATR)		(ɛ́l)(wɛ́:) 'to lean'	(lɛ́n)(tɛ́:) 'lost'	(jɔ̀ŋ)rɛ̀ 'work'
/a/	[ə] (+ATR)	(cə́wá:) 'sun'			
	[a] (- ATR)		(áfá:) 'melon'	(bàa)ŋà 'elephant'	(bàa)ŋà 'elephant'
/ ɔ/	[o] (+ATR)	(kólɛ́:) 'to change'			
	[ɔ] (- ATR)		(ɔ́r)(kɛ́:) 'strangle'	(bɔ̀b)(lɔ̀:) 'big'	(kās)kɔ́ 'bird'

(46) shows these allophones on a vowel chart. The –ATR allophone is below the dotted line in the three non-high vowels. Observe that while we consider only heads or non-heads in footed syllables, the separation between the two allophones is reasonably clear even across speakers, especially for the /a/ vowel. This supports the case for allophones rather than undershoot. If the vowels from stray syllables were added, the distinction would be less clear, possibly suggesting a gradient change and an analysis in terms of undershoot. But we will initially consider the case for ATR allophones.

(46) *First and second formants (vowel means from twelve male speakers)*



[ə] and [ɨ] have similar formants in some words, but are distinguished on analytical grounds because [ɨ] is found in roots and is active in triggering raising, whereas [ə] is only found as an alternate of [a], and takes no part in triggering raising. [ɨ] acts as a high vowel whereas [ə] does not. [9]

The following chart shows the binary features[10] that would be necessary to distinguish between the vowels, including the alternates. The ATR feature is separate as the analysis of undershoot would make this column redundant.

[9] This gives extra support to an issue discussed in chapter 3: Is vowel harmony really a phonological process in Kera or simply a case of co-articulation? The difference between the behaviour of these two vowels that are phonetically similar would suggest that the harmony is phonological.

[10] [Round] and [High] could be privative, but for this section on the [ATR] feature, all features are presented as binary for simplicity.

(47) *Vowel features*

		[high]	[back]	[round]	ATR
/i/	i	+	-	-	+
/ɨ/	ɨ	+	+	-	+[11]
/u/	u	+	+	+	+
/ɛ/	e	-	-	-	+
	ɛ	-	-	-	-
/a/	ə	-	+	-	+
	a	-	+	-	-
/ɔ/	o	-	+	+	+
	ɔ	-	+	+	-

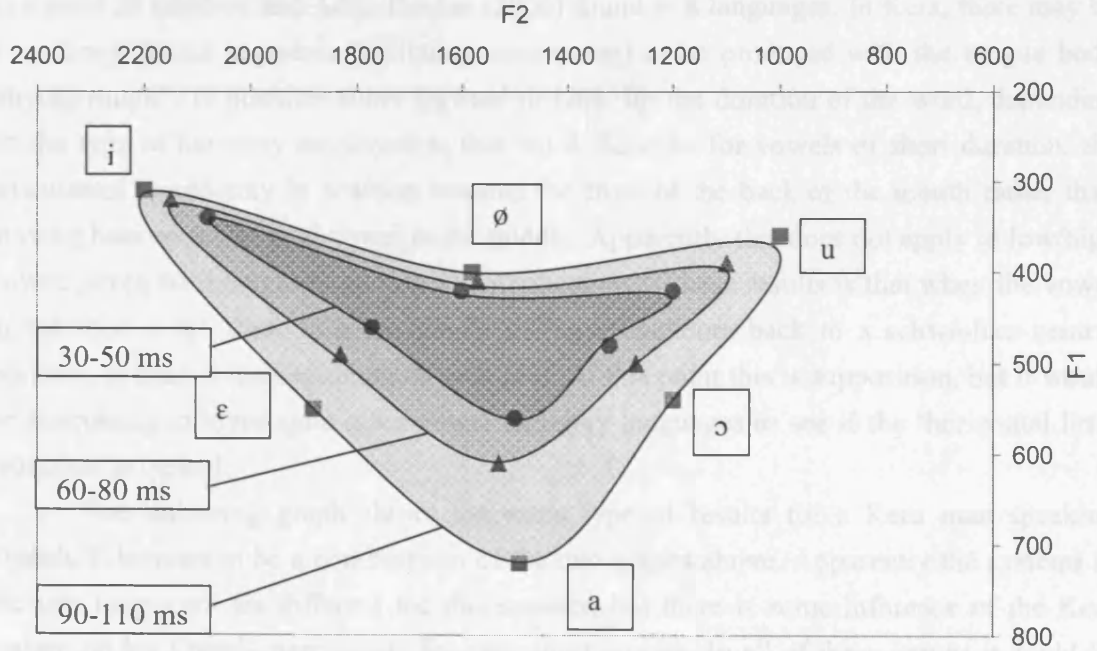
It is not uncommon to use the feature [ATR] in the analysis of African languages, but normally the feature is introduced in languages showing ATR harmony such as many Niger Congo languages (Leitch 2001), and Nilo-Saharan languages (Hyman, p.c.). Some linguists including Clements (2000), Parkinson (1996) and Kutsch Lojenga (p.c.) have reservations about using ATR in languages like Kera as they believe that tongue root advancement is only active in ATR harmony systems, However, other linguists including Archangeli and Pulleyblank (1994), Hyman (1988, 1998), Ladefoged and Lindau (1986) and Ladefoged (1980) are happy to use it, whether or not they are sure that tongue root advancement is involved, and this is particularly the case for contrasts involving [e]:[ɛ] and [o]:[ɔ] (Schane 1990, Casali 2003). Ladefoged & Maddieson (1996) argue that enlargement of the cavity might be a better description. They discourage overuse of the term ATR. So the situation is not clear cut. In this thesis, I continue to use the feature [ATR] as a short hand while being aware that the tongue root may not be the principle articulator for this feature. In phonological terms, the most important observation is that in the analysis that includes allophones, this feature must be distinguished from the height system.

If I continue with the allophone analysis, I need to say that [non-high,+ATR] vowels are non-stressed and [-ATR] vowels are stressed. I can then follow an analysis along the lines of Beddor et al. (2001) and de Lacy (2002a) who both note a correlation between stress and vowel quality. De Lacy observes that Giyarati low vowels attract stress away from mid vowels. He concludes that stressed mid vowels are more marked than

[11] Due to the flexibility of distinctive features theory, we are able to classify [ɨ] and [ə] as +ATR. This assumption will be useful to us in the analysis. However, it should be said that for some linguists, this kind of flexibility gives too much freedom in redefining segments according to our needs rather than according to their articulatory features.

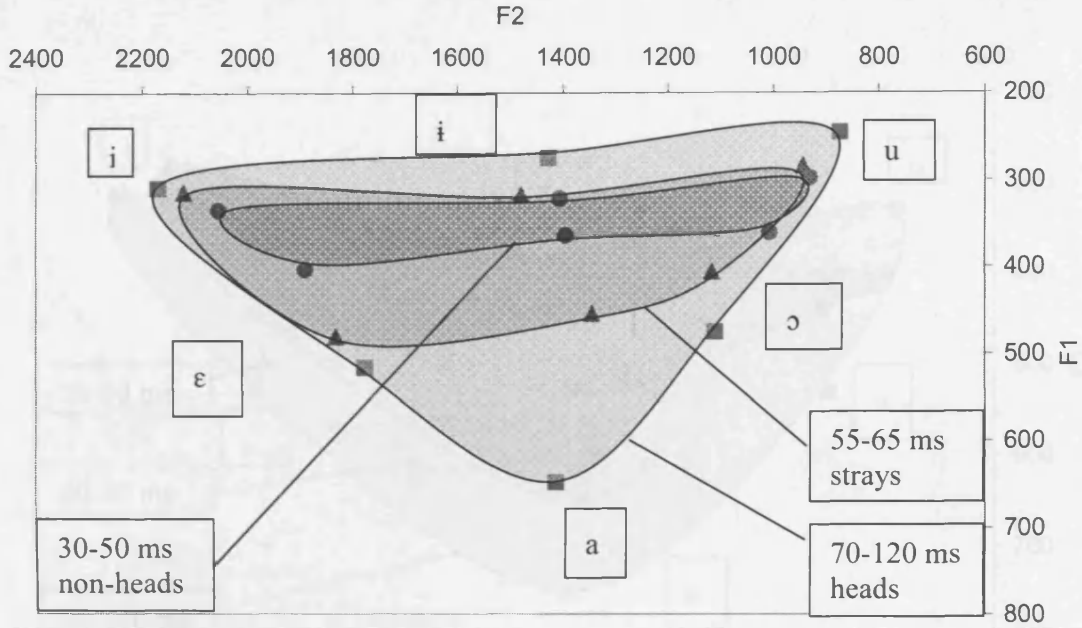
The two diagrams below show the quality differences in French (49) and Kera (50) vowels as they are affected by duration. The French data are taken from Gendrot and Adda-Decker (2005), but including only the vowels which are most like Kera vowels for comparison. In both languages, a case could be made for the non-high vowels spreading further from a schwa like sound as the duration gets longer, and in both languages, the quality of the high vowels is less affected by duration. In Kera, the F2 value does not change much with duration whereas in French there appears to be more of a change. This means that French and all the other languages measured by Gendrot and Adda-Decker appear to converge in concentric polygons to one vowel as the duration decreases, whereas Kera would appear to converge to one horizontal line of height with frontness and rounding unaffected by duration. Vowel harmony may have a role to play here in counterbalancing the convergence to a point. It should be noted too that the height information is not neutralized at word level because the non-head vowels only appear in words which also have a head vowel and the difference in F1 is clear for the high or non-high head vowels.

(49) *Measured mean average values of F1 and F2 for French vowels according to duration, data from Gendrot and Adda-Decker (2005), selected vowels only*



/a/ in Kera to the presence of a similar [+low] feature in /h/ and /ʔ/, but this does not explain similar non-reduced vowels for /ɛ/ and /ɔ/. For these vowels, we cannot look at fronting effects because /ɛ/ already is a front vowel and /ɔ/ never undergoes fronting, but the quality of non-reduction is clear.

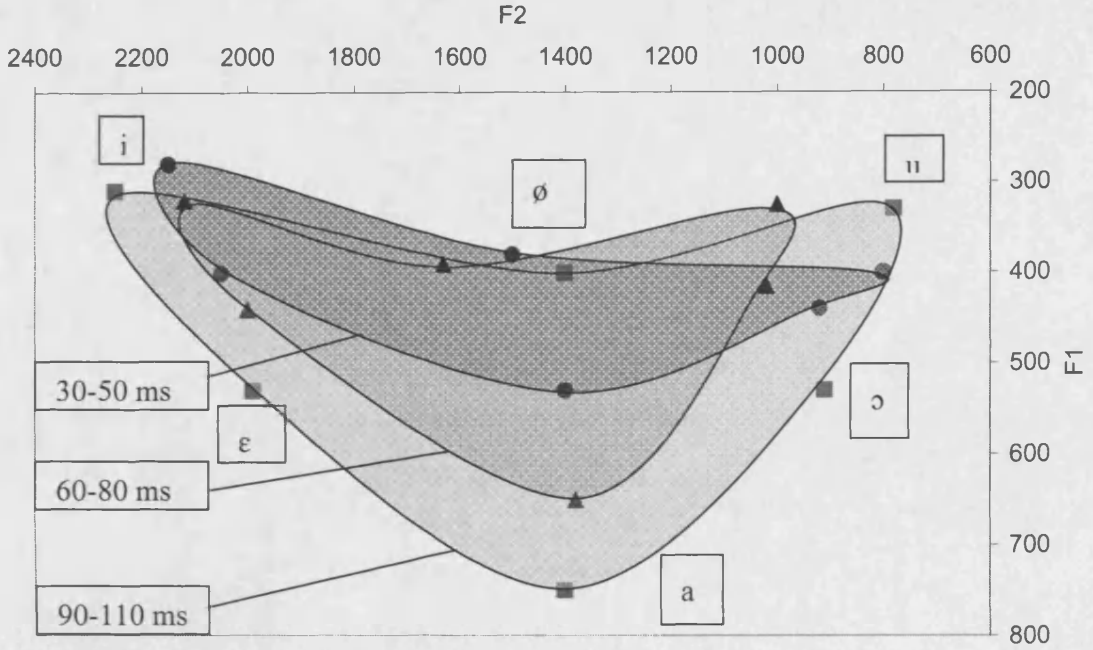
(50) *Measured mean average values of F1 and F2 for Kera vowels according to duration*



(50) shows us that in Kera the convergence is to a horizontal line rather than convergence to a point as Gendrot and Adda-Decker (2006) found in 8 languages. In Kera, there may be a tendency for all segments (including consonants) to be produced with the tongue body staying roughly in position either forward or back for the duration of the word, depending on the type of harmony employed in that word. So even for vowels of short duration, the articulators would stay in position towards the front or the back of the mouth rather than moving back to the neutral vowel in the middle. Apparently this does not apply to low/high vowels, even with height harmony. The implication of these results is that when the vowel in the root is /a/, there is a movement of the articulators back to a schwa-like neutral position, at least at the beginning of each foot. At this point this is supposition, but it would be interesting to investigate other vowel harmony languages to see if the 'horizontal line' reduction is typical.

The following graph shows the same type of results for a Kera man speaking French. It appears to be a combination of the two graphs above. Apparently the systems in the two languages are different for this speaker, but there is some influence of the Kera pattern on his French, particularly for very short vowels. In all of these graphs it could be argued that the F1 values for non-high vowels changes according to duration, and it is possible that in French and Kera, there is a non-categorical relationship between the F1 value and the duration so that both increase together until the target F1 value is reached. The case is not clear cut however as (51) could be used in support of a phonological distinction between short (non-head) vowels and other vowels.

(51) *Mean average of F1 and F2 according to duration, French vowels of a Kera speaker*



Returning to Kera, the –ATR/higher F1 quality also appears in light syllables which are vowel initial such as in (VCVC) words. So we get [agay] 'hoe' and not *[əgay] even though it is a non-head syllable. In the absence of an onset, the initial vowel duration has a mean of 60.8 ms ± 12.8. This choice of allophone cannot be explained by the position within the foot, but is consistent with the view that the F1 value correlates with the duration of the vowel. This supports the phonetic view of a continuum in quality and duration. Words beginning with [h] act like vowel initial words.

The discussion so far has assumed that the duration is affecting the vowel quality. There is the option of the reverse process taking place. Barnes (2006), based on Crosswhite (2001), presents two possibilities. Either there is prominence-reducing vowel reduction, in which case the lack of stress means a reduction in quality in a desire to avoid effortful articulations, or there is vowel undershoot in which case there is insufficient time to produce the quality in non-high vowels. The first of these options tends towards being categorical and the second gradient. In the Kera case discussed here, undershoot seems more likely because of the gradient nature of the results (although the division between [a] and [ə] does not seem gradient) and because only non-high vowels are affected.

The results in (50) suggest that the allophone approach needs to be considered as tentative. If we only had the head and non-head data, an allophonic analysis would seem to fit best, but with the stray syllable and vowel initial data, and with the comparison with French, the picture is much less clear. However, I have continued to refer to 'allophones' in this thesis, while acknowledging that these quality changes could be phonetically based as a

result of insufficient time to reach the target vowel. Even if we decide that this is undershoot we will still conclude that non-head vowels are shorter and reduced precisely because they are non-head vowels. So if we argue for undershoot rather than allophones, it still leads us to the conclusion that Kera has feet. The non-head vowel leads to a short duration and the short duration leads to undershoot. So although the analysis of the 'allophones' is open to debate, the main claim of this chapter concerning the existence of iambic feet in Kera is clearly supported by the vowel quality and duration data.

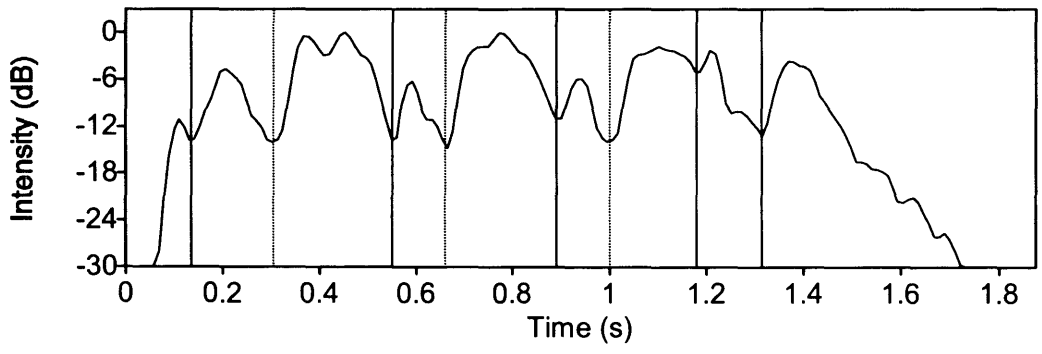
2.2.4 Intensity

Traditionally, the cue which is used the most as evidence for foot structure is the stress placed on head vowels. In Kera, stress is not particularly noticeable, and there is no pattern where one syllable is more intense than all the others giving rise to a word accent. Nevertheless, intensity is used at the level of the foot and this can be measured. The intensity is greater for the head of the foot. There is a consistent difference between heads and non-heads. In the following example (taken from Pearce 2006a), which is a typical plot of intensity, all heads apart from the first (which is a function word) have approximately the same intensity. All non-head syllables have a lower intensity, with a mean difference of 5 dB (±1.0) between each non-head and head. Heads are underlined.

(52) Tɛ̄n āsáŋ kəbāwkəbāwwɛ̄ bà 'I did not see a bat' (Pearce 2006a)

I saw bat not

Tɛ̄n (ā sáŋ) (kə bāw) (kə bāw)(wɛ̄:) (bà:)



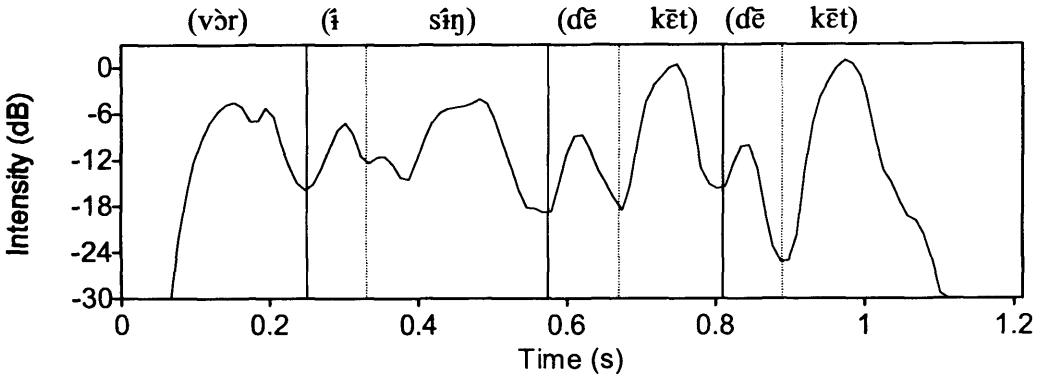
Solid lines indicate foot boundaries, while interrupted lines indicate a syllable boundary within a foot.[13] The next example shows that the same patterns of intensity are found on a variety of vowels. Greater intensity is placed on both of the heads of the final word, which

[13] It is interesting to note in this example that although the word [asaŋ] has a -ATR initial vowel, as expected in vowel-initial words, and it has a longer duration than would normally be expected for a non-head, the intensity shows that the first syllable is not a head.

is an ideophone, for extra emphasis. The mean difference of intensity between non-heads and heads on the emphasized word is 8.5 dB (±0.71).

(53) Vɔ̀r ɪ̂sɪ̂ŋ dɛ̄kɛ̄t-dɛ̄kɛ̄t 'The river stays calm' Pearce (2006a)

river sits calm



2.2.5 Vowel harmony

Kera exhibits several types of vowel harmony and not all of them refer directly to the foot as the domain of spreading, but for most types, the domain is the Prosodic Word which is defined in terms of feet. The Prosodic Word is made up of all of the feet within the word, excluding stray (unfooted) syllables. So for the types of harmony which involve the Prosodic Word, the foot structure is still key.

However, the main evidence for the foot in Kera vowel harmony is in the Fronting Harmony where front suffixes cause central vowels in the same foot to front (54a). Between feet, the fronting does not take place (54b). If Kera does not have a foot structure, these harmony facts are hard to explain. Underlining here indicates the affected vowel.

(54) *Fronting within the foot*[14]

-ɛ 'imperfective'

(a) Fronting within feet:

bàl-ɛ → (bɛ̰̀lɛ̀:)	'love'	bɪ̀ŋ-ɛ → (bɪ̰̀ŋɪ̀:)	'open'
ɪ̄s-ɛ → (ɪ̰́sɪ́:)	'sit down'		

(b) No fronting between feet:

bàad-ɛ → (bàa)dɛ̀	'wash'	vɪ̀ɪ̄g-ɛ → (vɪ̰̀ɪ̰̄)gì	'empty'
ɪ̄sk-ɛ → (ɪ̰́s)kí	'hear'		

[14] These examples also contain height harmony -ɛ→-i, which is not restricted by foot structure.

Chapter 3 gives a detailed analysis of vowel harmony in Kera with several more examples of the role of the foot. So no more is said here except to emphasize that the harmony facts give strong supporting evidence for the existence of the foot in Kera.

2.2.6 Tone spreading

I will equally not spend time on the tone facts here as chapters 4 to 6 of this thesis are centred on different aspects of Kera tone. But I briefly summarize the most salient facts concerning the foot structure.

In three syllable words with two tones, the domain of the first tone is a foot.[15]

(55) Low High (gə̀dàa)(mɔ́:) 'horse' (dàk)(tə́láw) 'bird' *(gə̀dáa)(mɔ́)
High Low (kə́sáa)(bɔ̀:) 'locust' (mán)(də̀hàŋ) 'sack' *(kə́zàa)(bɔ̀)
High Mid (kúɓúr)(sī:) 'coal' (sáa)(tərāw) 'cat' *(kúɓūr)(sī)

The domain of the first tone cannot be determined by counting syllables. Instead, the first foot is the domain for the first tone, and the domain for the second tone starts with the second foot.

It is possible to find two distinct tones on one foot. But this situation only occurs when the word only has one foot. E.g. *bèdɛ́w* 'millet drink'. In Kera, the foot is preferred as a tone bearing unit rather than the syllable, but if the word has two tones and only two syllables, the tones must be realized, so one tone associates with each syllable. There are no contour tones.

This reference to the foot structure in Kera tone is reasonably unusual, but there are hints of similar patterns in other Chadic languages such as Hausa (Newman 2000, Lahrouchi 2005), in Migaama (Roberts 2005), in Kanakuru and Bole (Newman 1972). Certainly outside of the Chadic language family there is evidence in certain languages for a relationship between tone distribution and feet. These include Bambara (Leben 2003, Weidman and Rose 2006), Chilungu (Bickmore 2003) and Ayutla (de Lacy 2002b).

For more details on Kera tone and the relationship between tone and the foot, see chapter 4.

---

[15] Bisyllabic feet with a single high tone are actually realized with the high tone on the non-head first syllable lowered to mid. In later chapters I discuss whether this means there is no spreading or whether it is undershoot with the tone bearing unit being the foot. I conclude that the foot has a target which is reached towards the end of the head vowel, but that the domain for the tone encompasses the whole foot. In order to avoid confusion, I mark both tones as H in the examples even though phonetically some of them might be more like M.

2.2.7 Perception

Certain informal perception tests indicate that the Kera speakers may have some sort of internal knowledge of the foot structure in Kera. Although not enough tests have been run to give any solid statistical evidence, the fact that certain speakers can pick out patterns that indicate foot structure suggests that there must be some structure there for them to find.

A Kera speaker was asked to say certain phrases slowly. Instead of lengthening each segment, he introduced extra pauses. In repeating the same phrases, the placing of the pauses changed, but these pauses were always situated between feet. This suggests he treats each foot as a minimal word and that the foot is psychologically real to him.

(56) /Tɛn asaŋ kul(i) nuutuŋ/ 'I saw his house'

(a) (slow): (Tɛ̄n)..... (ásáŋ).....(kūl)..... (núu)....(túŋ)

(b) (slow): (Tɛ̄n)..... (ásáŋ).....(kūl).....(ī:)..... (núu)....(túŋ)

(c) (slow): (Tɛ̄n)..... (ásáŋ).....(kū:).....(ī:)..... (núu)....(túŋ)

(57) /Tɛn bɨ gɔlɛ cəwaŋ/ 'I am looking at the sun/fire'

(slow): (Tɛ̄n).... (bɨ̄ gɔ̀l).....(cə́wáŋ)

The examples above show us that this speaker has a unit of division between the syllable and the word. (asaŋ) is bigger than a syllable, while (nuu) is smaller than a word.

A similar result arose when two other men were asked to clap 'important beats' while saying phrases. They clapped only the heads of feet. This was done consistently over about 10 sentences with no initial instructions as to what 'important beats' might mean. In tests with nonce words, they were also able to assign the correct tone to a syllable according to its position within the foot. For example, given a nonce word such as *gerɛmtɛŋ*, and being told that the tone starts low and ends high, the tonal pattern they gave was *(gèrèm)(tɛ́ŋ)*, but when they were given a nonce word like *barnəpaw*, their tonal pattern was *(bàr)(nə́páw)*, with tones in the same foot sharing the same tone. Although this is anecdotal evidence, it suggests that at least on some level, the Kera are aware of the foot in terms of rhythm, parsing and in tone spreading domains. Together with the other evidence already presented, it makes a strong case for the existence of the foot in Kera.

Kera speakers were also asked for judgements on the best way to spell words. This revealed whether they counted transitions as vowels or not. In about 50 ambiguous words which I claimed had transitions and in 50 other words which did not, four Kera speakers decided unanimously that all of the transitions did not exist and that all of the vowels did. At no point did they suggest a spelling which would imply a (CVCV) foot. This was

despite the fact that some of them had seen some of these words spelt with the transition written as a vowel.

2.2.8 Syllabic nasals

So far in this chapter, I have not commented on syllabic nasals and the effects that they have on foot structure. We have no way of knowing if the word final (C)Ṇ might be within or outside a foot. However, the 1 sg possessive suffix –ṇ on inalienable nouns does affect the duration and the quality of the vowels in the noun root in a different way from other consonant suffixes, and the only way I can explain the differences is to posit a foot structure, and to claim that there is some sort of underlying syllable structure which at least marks the syllabic nasals as syllabic.

(58) shows a syllabic nasal following a root syllable with the structure CVC-. I compare this with the 2 sg m suffix –m.

(58) bàr-ṇ > (bàr)ṋ 'my father'

(bàr)ṋ	[a]	[n]
F1:	**634** Hz	-
duration:	**67** ms	84 ms

bàr-m̀ > (bəràm) 'your father'

(bəràm)	[ə]	[a]	[m]
F1:	**468** Hz	633 Hz	-
duration:	**31** ms	85 ms	65 ms

In (bàr)ṋ, the duration and F1 value of [a] show that it is a head vowel whereas the duration and F1 value of [ə] in (bəràm) is very different, and in keeping with it being a non-head vowel. This is confirmed by the measurements of the following [a] which suggest that the epenthetic vowel is now the head vowel in a disyllabic foot.

Clearly, with the –m suffix, there are changes that suggest a weak-strong foot. But with the syllabic nasal, there is no such shortening and lengthening. Through the syllabic nasal suffix, we are able to see the underlying form of the root. Without it, the underlying form would be supposition. The only way that these changes between suffixes can be reasonably explained is by referring to foot structure: With the syllabic nasal, the first syllable is a heavy syllable and therefore a foot in its own right. For the –m suffix, an epenthetic vowel is required because no consonant becomes syllabic if it is not underlyingly syllabic and this avoids a 3 consonant cluster. So the structure becomes a disyllabic iambic foot (CVCVC). The non-head is reduced in length and quality while the head lengthens slightly. Any discussion that focuses only on weight, without taking feet into account, is going to struggle here. The [a] in *b□ram* is longer than the [a] in *bar* because the iambic structure causes some phonetic lengthening of the head vowel.

2.2.9 Epenthetic vowels

Epenthetic vowels do not get lengthened in any circumstances. The function of epenthetic vowels is to break up unacceptable consonant clusters, but they appear to be limited in how much weight they can carry. We might want to claim that they are weightless, except that Epenthetic vowels can have exactly the same duration and quality as head vowels in (CVC) feet, so claiming that they have no mora (and are therefore on a level with transitions) seems an unpromising claim to make. To verify whether epenthetic vowels do act like heads, 20 (CVC)(CVC) words were compared with 13 (CVC)(C-C) words where an epenthetic vowel has been inserted before the suffix. The mean duration for the final root vowel was 52 ms, and the mean duration for the epenthetic vowel was 51 ms. Clearly there was no significant difference between them in duration. This was the case for the quality too. Piggott (1995) claims that epenthetic vowels may lack weight, with examples from Mohawk and Iraqi Arabic, and Kager (1999a) states that although epenthetic segments are fully-fledged output segments which can participate in phonological processes, they can't be heads because only inputs are licensed to be heads. The Kera data suggests otherwise. But epenthetic vowels are different from input vowels in that they do not lengthen. So in the next example, we do not see lengthened epenthetic vowels.

(59) /mɨnt-t-n-u/ > (mɨ̄n)tū̲ (tū̲nū:) *(mɨn)(tu̲tu̲:)(nu:) 'repeatedly called him'
vowel duration in ms. 78 27 39 176

The lack of lengthening fits well with one of the pieces of evidence from Hyman (1985) for weightless epenthetic vowels. But they do not fit the other criteria that he gives as they generally do participate in footing except for words of four syllables or more, which are rare. In (60i) we see that words with epenthetic vowels behave like words with no epenthetic vowels (60ii).

(60) i. bal -t-t-Vm → (bàl)(tə̲tàm) 'love him habitually (emphatic)'
Duration: 71 25 62

ii. hɛbkanaŋ → (hɛ̄b)(kənāŋ) 'now'
Duration: 57 18 79

I therefore conclude that epenthetic vowels are not the same as transitions, they do carry weight, and they cannot carry the two moras that would be implied by a lengthened epenthetic vowel.

2.2.10 Minimal binarity requirement

Other evidence for iambicity comes from the minimal bimoraic foot requirement for lexical words and the need for all words to contain or be part of a foot. All nouns and verbs consist of or contain a heavy syllable. None of these words have the surface form *CV. Note however that the heavy syllable can be the one that contains the suffix and an epenthetic vowel rather than the one containing the root vowel, so we get: *fal-m* > *f□lam* 'find you'. These facts suggest that there is a bimoraic foot requirement. As with many languages, the requirement does not extend to function words. The function words often act as clitics, and the bimoraic requirement is fulfilled between the clitic and the following word.

(61) *Phrases showing function words acting as clitics (only the last foot is indicated)*

particle	utterance-final	non-phrase-final
/ta/ 'emphatic'	[wɨ pis (ta:)] 'It is good!'	[wɨ̄ pîs (tá̰ gɨ̌m)] 'It is good too!'
/ba/ 'negative'	[wɨ ju:nu: (ba:)] 'He didn't do it'	[wɨ̄ jù:nù: (bà̰ gɨ̌m)] 'He didn't do it either'
/pa:pa/ 'not'	[wɨ pa:(pa:)] 'It isn't there'	[wɨ̄ pá: (pá̰dà:)] 'It isn't there any more'

With multiple function words CVCV patterns do occur because lengthening is not permitted. The footing for these is unclear.

(62)	tɨ	bɨ	mɔ	-ŋ	'isn't it so?'	>	a. (tɨbɨmɔŋ)
emphasis	*of*	*question*	*def.art.*			or	b. tɨ(bɨmɔŋ)
						or	c. tɨbɨ(mɔŋ)

Note that function words can be heads if accompanied by a consonant coda.

(63) bɨ mɔ-ŋ > (bɨmɔŋ) ɔ is in a function word and also a head vowel

The important point to note here is that lexical words are Prosodic Words and therefore have a bimoraic minimum requirement. All lexical words must contain at least one foot. These facts can be covered with the constraints LEXWD = PRWD (Vogel 1993, van Oostendorp 1999) and PRWD [FT]. However, these constraints do not hold for function words. Function words are not required to be bimoraic. If possible, they are incorporated into the following prosodic word as in the Italian and Spanish definite article (van Oostendorp 1999 and Kikuchi 2000). Function words in Kera can contain just one mora

and they are not under any obligation to lengthen in order to meet a minimal requirement of moras.

Verbs with multiple suffixes also raise an extra problem for our theory of parsing into feet. This is because some words could suggest the need for a ternary foot. Ternary feet have been posited for a few languages, mostly based on a trochaic foot. A three syllable foot of the form (σ σ σ) or (σ́ σ σ), where the accent indicates stress, has been suggested by Levin (1985, 1988), Halle and Vergnaud (1987) and Rice (1988), and is implied by Elenbaas and Kager 1999 with their use of the LAPSE constraint. A structure such as ([σ́ σ] σ) has been suggested by Dresher and Lahiri (1991) and Rice (1992). Rice (2006, 2007) suggests that the structure should be ([$\sigma_{\mu\mu}$] σ_{μ}) σ_{μ}. Kager (1994) has yet another way of dealing with the ternary pattern with a constraint that bans adjacent (binary) feet. No language has a ternary rhythm as the basic rhythmic unit (McCartney 2001), but where there are restrictions on stress or foot structure which cause feet to align to the left edge of the word and also to suffixes, this can lead to consecutive light syllables in the middle, such as in Estonian and Finnish (McCarthy and Prince 1995b, Hayes 1995), and in some languages, these are best interpreted as being part of ternary feet. In other languages, they are best interpreted as being unfooted syllables.

In Kera, we are dealing with iambic feet. In cases where the iterative –t and perfective –n are both present (or the doubled version of the iterative –t-t), together with a vowel suffix, my normal analysis falls down for some speakers, and I could posit ternary feet. However, another option is to allow a stray syllable between feet, and this is an option that I will claim is used by Kera speakers.

Clearly (64a.) is one option for words with multiple suffixes. But there is a second pattern of epenthesis which has three possible analyses (64b., c., and d). These three involve the inclusion of one more vowel between the [t] and [n]. Both versions, with or without the extra vowel, are heard by Kera speakers. The only way we can tell which of these are adopted by Kera speakers is to take careful acoustic measurements of a number of examples of words of this type.

(64) mirk-t-n-u > a. (mir)(kut)(nu:)
b. (mir)(kutunu:) c. (mir)kutu(nu:) d. (mir)ku(tunu:)

After a short investigation of the recordings of a few speakers, the following three systems emerged as the most likely structures. Each speaker appeared to use only one system, but this could also be a difference in rate of speech. More research is needed to determine all the factors involved in the choice of system, and to ascertain whether all three systems are in fact employed. Of the three, system 1 is most in doubt.

(65)

	System 1	System 2	System 3
a baad-t-t-n 'wash me (hab.)'	baadətətan	baadatətan	baadattan[16]
b. bal-t-t-n-u 'loved me (hab.)'	bɨltutunu:	bɨltutunu:	bɨltutnu:
c. baad-t-t-n-u 'washed him (hab.)'	bʉdututnu:	bʉdututunu:	bʉdututnu:

(66) These three systems can be analyzed in the following way

	System 1: Ternary, avoids strays	System 2: Final disyllabic foot, allows strays	System 3: Allows codas, avoids strays
a baad-t-t-n	(baa)(dətətan)	(baa)da(tətan)	(baa)(dat)(tan)
b. bal-t-t-n-u	(bɨl)(tutunu:)	(bɨl)tu(tunu:)	(bɨl)(tut)(nu:)
c. baad-t-t-n-u	(bʉ)(dutut)(nu:)	(bʉ)dutu(tunu:)	(bʉ)(dutut)(nu:)

My assumption is that each of these systems can be produced by a slightly different grammar. As none of these forms are very common, there is more likelihood of differences between individual grammars co-occurring within one community. Because these forms are rare in natural speech, the only way to measure these consistently is to ask a speaker to produce several of these forms in a controlled setting. This was done, and careful measurements were taken of one speaker. The results show that he consistently chooses system 2. This does not imply that all speakers use this system, but we will look at the evidence which points towards system 2 in this case. Over 50 words with multiple suffixes were measured for amplitude, vowel quality, duration and tone:

(i) *Amplitude.* We would expect the amplitude to be greatest for heads and least for non-heads, or maybe stray syllables. In all cases the first and last syllables had the greatest amplitude. In (66a), the third syllable (or transition from [t] to [t]) had the weakest amplitude. In (66b), the middle syllables were equally weak. In (66c), the third syllable was weakest. Pictorially, this can be represented as follows:

[16] In [tt], the first t is released, but the transition between the first and second t is not long enough to be considered an epenthetic vowel.

(67) a.

b.

c.

Note that all of these examples have the main prominence at the beginning and the end of the word. So it seems that this is what is defined by the common grammar. These results suggest that system 2 is being used as systems 1 and 3 have head syllables where the amplitude is weakest. But this result alone is not enough as it could be argued that the weakest amplitude corresponds to the two voiceless [t] stops and that the lesser amplitude could be due to devoicing of the vowel in between.

(ii) *Vowel quality.* Looking particularly at words with /a/ vowels, heads should have an [a] quality, non-heads an [ə] quality and stray syllables, something between the two. The results were as follows:

(68) a. [a a/ə ə a]
b. [a a/ə ə a]
c. [a a/ə a/ə ə a]

This supports system 2 or possibly system 3. It seems unlikely that this could support system 1.

(iii) *Duration.* The average duration of vowels were as follows (in ms.):

(69)	a.	90	51	31	70	
	b.	70	47	43	90	
	c.	90	47	40	15	70

The first and last syllables are evidently heads. A duration of around 50 ms would suggest a stray syllable, whereas a duration of around 20-30 ms suggests a non-head syllable. A duration of around 10-20 ms could be a non-moraic transition. None of the systems fit these figures exactly, but system 2 fits the best.

(iv) *Tone.* Considering only words which start with a low tone and end with a high tone, we would expect a non-head syllable between the L and the H to maybe exhibit a M tone because the syllable is too short for the H tone target to be reached. But if the syllable between the L and the H is a head syllable, we would expect the target to be reached. The

tones were produced as follows (where M is a phonetic level rather than a phonological M tone):

(70)	a. and b.	L M H H
	c.	L M H (H) H

System 3 does not fit well with the results in a. and b. as system 3 has head vowels in the second syllable slot. Systems 1 and 2 are supported by these results.

Overall, I conclude that this speaker is using system 2. This system allows strays and a final disyllabic foot.

Note that although these systems approach strays and the binary nature of the foot in different ways, all of them require the existence of the foot. For this reason, they lend further support to the hypothesis of this chapter: that Kera has a metrical system. In the next section which looks at an OT analysis of the foot, the facts presented here will also be included in the analysis. This analysis will make further predictions about which systems are viable.

2.2.11 Conclusion concerning Kera foot structure

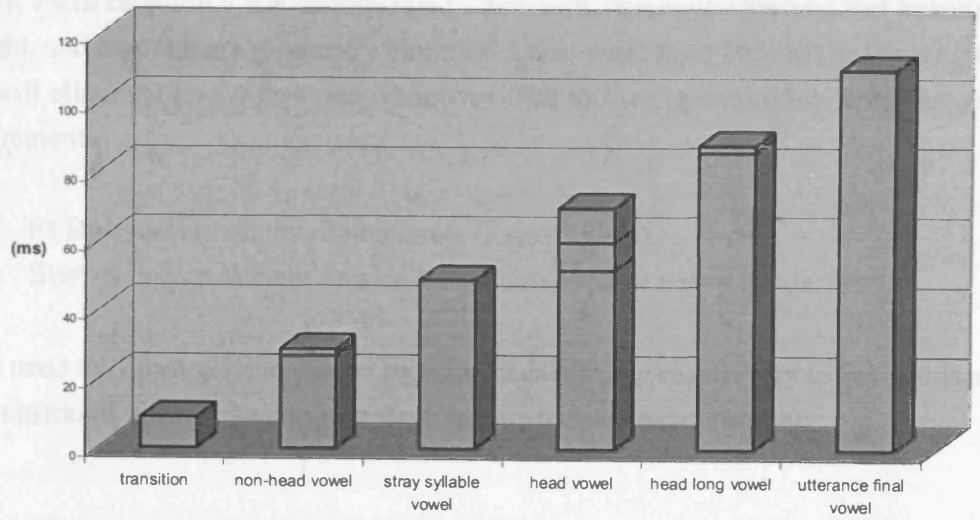
The whole of this chapter so far has given evidence for the existence of the Kera foot. Probably each section could stand on its own as proof enough, but taken together, the evidence is very strong. I conclude that Kera does indeed have an iambic foot. The head of the foot has the weight of two morae. If the vowel is a non-high vowel, it will be realized with a -ATR vowel. The non-head has the weight of one mora and a +ATR vowel. Non-footed syllables, which can appear phrase-finally, have a -ATR vowel. The duration of a vowel depends on its position in the foot and the phrase. The quality of the vowel appears to be dependent on the duration. The following chart gives comparative durations and categories for various segments and syllables. At least 20 words were measured for each category.

(71) *Vowel duration and quality*

vowel		duration (ms)	quality of vowel	morae in syllable
transition	...C-C...	9	-	-
non-head, open syllable	v in (CvCVC)	27	+ATR	1
	epenthetic v in (CVC)(CvCVC)	29	+ATR	1
	v in (CvCV:)	29	+ATR	1
non-footed, open syllable	V in CV] phrase-final	49	-ATR	1
head, closed syllable	V in (CVC)] phrase-final	52	-ATR	2
	V in (CVC) word	60	-ATR	2
	first V in (CVC)(CVC)	60	-ATR	2
head, disyllabic foot, closed	V in (CvCVC)	70	-ATR	2
head, open syllable	VV in (CVV)	86	-ATR	2
	V: in (CvCV:)	88	-ATR	2
open vowel utterance final	CV:: in Int phrases	110	-ATR	1 or 2

The graph below shows the results from the table above with the durations for vowels under the same category combined. The different values in each category are shown as lines on the same column. In most cases, these are very close to each other. The one case with more diversity is in the head vowel category. This is because the vowel in the head of a disyllabic foot is longer than the vowel in a monosyllabic foot. This is presumably a case of phonetic lengthening to make the iambic nature of the foot more prominent.

(72) *Comparison of vowel duration*



The evidence is clear that Kera does have a foot structure. Parsing and vowel harmony takes place at word level. At phrase level, adjustments are made to unparsed material so that there are no breaks in the series of well-formed feet. Unfooted material is only permitted at the right edge of the phrase and where there is a series of epenthetic vowels or function words. The adjustments to light syllables can take one of three forms: (i) Parsing the light syllable with a following heavy syllable to form a foot. (ii) Deleting the vowel so the consonant forms a coda and makes the previous syllable heavy. (iii) Lengthening the vowel in the light syllable to make the syllable heavy. Kera has a preference for strategies (i) and (ii), but (iii) takes place if (i) and (ii) would not make a series of well-formed feet.

Having convinced ourselves that the Kera foot exists, we now move on to consider the OT analysis of the main facts that have been presented in this section concerning Kera feet.

2.3 OT analysis on foot structure

2.3.1 Constraints on types of feet

An adequate analysis of Kera feet will need to cover the following facts:

(73) *Facts to cover in OT analysis*
(i) There are only (∪ -) and (-) feet
(ii) ∪ ∪ → (-) phrase-medially (vowel deletion) and ∪ - phrase-finally (vowel lengthening)
(iii) - ∪ → (-) ∪ phrase-finally, leaving an unfooted syllable (no lengthening or deletion)
(iv) There is no ∪ ∪ sequence (except for epenthetic vowels and function words)
(v) - ∪ # ∪ - → (-)(-)(∪ -), (vowel lengthening)
(vi) - ∪ # - → (-)(∪ -) (combination across word boundary)

Firstly, I will establish a few undominated constraints. We have observed that parsing is left to right, and that feet are minimally bimoraic. I also want to ensure that heads are heavy as this will eliminate (∪ ∪) feet (see (i) above). The following constraints will give us these requirements:

(74) FT BIN: feet are minimally bimoraic (Kager 1999a)
(75) SWP (Stress-to-Weight Principle): If Stressed, then heavy (Kager1999a).

I also need the constraints to favour right-headedness. The easiest way to cover this and the two constraints above is to combine them in an undominated constraint:

(76) FTFORM(IAMB): Feet are iambic[17] (Buckley 1999, Kager 1999a)

This is a cover constraint which includes the requirements that the foot be right headed, that the head is heavy and that the non-head is monomoraic.

I also wish to avoid super-heavy syllables:

(77) *3μ: a syllable is at most bimoraic (Kager 1999a)

The tableau in (78) shows how most types of parsing will be eliminated with these constraints. We are left with the two that we require.

(78) /∪ ∪/ *input (The head syllable is indicated by acute accent)*

/∪ ∪/	*3μ	FTFORM(IAMB)
☞ (∪ ́-)		
☞ (́-)		
(- ́-)		*!
(- ∪́)		*!
(∪ ∪́)		*!
(́-) ∪		*!
(∪́)		*!
(∪ =́)	*!	

= symbolizes superheavy

This ranking means that I can now omit super-heavy and (∪ ∪) feet from the list of candidates. From this point on, I will use the notation of the CV structure so that we can examine heavy syllables with long vowels and closed syllables separately. So far in this chapter I have used the notation of V: for lengthened vowels and VV for lexical long vowels, but I have acknowledged that there is no difference in the duration of these two vowels. Therefore, in the tableaux I will simplify the situation by including both types under the notation VV.

[17] Eisner (1997), and Kager (2002) argue successfully that FtBin, FootForm and Align constraints can all be described in terms of more localised constraints such as Lapse. This goes beyond the scope of this thesis, but their constraints could equally have been used here.

2.3.2 Constraints concerning the position in the phrase

The second point I wish to cover is (64ii) ∪ ∪ → (-) phrase-medially (vowel deletion) and (∪ -) phrase-finally (vowel lengthening). With lengthening and deletion both used as strategies for avoiding a CVCV structure, the following constraints must be low ranked.

(79) DEP-μ: Output morae have input correspondents. (Kager 1999a)

(80) MAX-V: Input vowels must have output correspondents. (Kager 1999a)

Wherever possible, deletion is preferred to lengthening in Kera, so rather than increase the weight of a syllable, a vowel will be deleted. This means that DEP-μ dominates MAX-V.

The following tableau demonstrates this grammar:

(81) /∪ ∪/ *input, non-phrase final (head underlined)*

/CVCV/	FTFORM(IAMB)	DEP-μ	MAX-V
☞ (CVC)			*
(CVCVV)		*!	
(CVCV)	*!		

Our mini grammar is now:

(82) *3μ , FTFORM(IAMB), DEP-μ » MAX-V

In phrase final position, a /∪ ∪/ input does not reduce to (-). In this case, the avoidance of (∪ ∪) feet is achieved by lengthening rather than deletion. The reason for this is that segments cannot be deleted at the right edge of a phrase. As deletion is no longer permitted as a strategy, lengthening is chosen instead.

To cover this, I need a positional faithfulness constraint that recognises that edges are prominent positions and which assures that the vowel at the right edge of the Phonological Phrase is not deleted. As the Phonological Phrase boundary coincides with the right edge of the XP, I introduce an ALIGN constraint to link the phonological phrase and the XP. There are various ways in which languages can align the phonological phrase with the ends of syntactic constituents (Selkirk 1986, Truckenbrodt 1995, Dehé 2004 and Hellmuth p.c.). Selkirk (1986) proposes a relationship between the syntactic and prosodic structures defined in terms of the ends of the syntactic constituents. I will follow a similar approach here, without going into details for reasons of space:

(83) ALIGN R XP: The right edge of the Phonological Phrase is aligned to the right edge of the XP.

(84) MAX V]$_{PP}$: Input vowels must have output correspondents at the right edge of the Phonological Phrase[18]

The ALIGN constraint is assumed to be undominated, and therefore not included in the tableau. If MAX V]$_{PHONP}$ is higher ranked than DEP-μ then the candidate (CVC) is eliminated when considering a word at the right edge of the Phonological Phrase.

(85) /∪ ∪/ *input, phrase final*

/CVCV/	FTFORM(IAMB)	MAX V]$_{PP}$	DEP-μ	MAX-V
☞ (CVCVV)			*	
(CVC)		*!		*
(CVCV)	*!			

Tableau (85) did not include the unparsed output CVCV. At this point in the analysis it would be the winning candidate with no violations. I will exclude this candidate below in (97).

The effects of the MAX V]$_{PP}$ constraint emerge only at the right edge of a phonological phrase. Elsewhere, the ranking which I have already established will prefer deletion to lengthening.

In the above tableau, I also did not include (CVV)CV as a candidate. The reason that (CVCVV) is preferred to (CVV)CV is that in the second option, not all syllables are parsed. I therefore need the following constraint:

(86) PARSE-σ: All syllables are parsed into feet. (Kager 1999a)

This constraint is combined with DEP-μ in the following tableau. Note that while DEP-μ is violated by the winning candidate, this does not affect the result because the other candidates also violate this constraint. DEP-μ is needed to rule out the possibility of both syllables being lengthened.

[18] There is a more elegant solution that might be worth considering within Span Theory as proposed by McCarthy (2004). This would make the Phonological Phrase a span with the element at the right edge of the phrase as head. We would then have the constraint MAX HD SPAN which would rule out the possibility of deleting the final element in the phrase.

(87) /∪ ∪/ *input, phrase final*

/CVCV/	DEP-μ	PARSE-σ
☞ (CVCVV)	*	
(CVV)CV	*	*!
(CVV)(CVV)	**!	

In this tableau, the ranking of these two constraints is not yet established. But in the following discussion, we will see that for a /- ∪/ input in phrase-final position, DEP-μ must be ranked above PARSE-σ.

I must first exclude the possibility of shortening of the long vowel for any inputs with heavy syllables:

(88) MAX-μ: Input morae have output correspondents

In the following tableau, this constraint eliminates all the candidates with vowel shortening in the first syllable. The candidate (CVC) is also eliminated by the MAX V]PP constraint.

(89) /- ∪/ *input phrase-final*

/CVVCV/	MAX-μ	MAX V]PP
☞ (CVV)CV		
(CVC)		*!
(CVCVV)	*!	
(CVCV)	*!	

Some attention is needed here to make sure that the high ranking of MAX-μ does not affect the winning candidates in the cases already discussed. At first glance, it would seem that /CVCV/ → [CVC] in phrase-medial position violates MAX-μ. However, in this case, the onset of the second syllable becomes the coda of the first syllable and in the process, it adds extra weight to the syllable. Both CVCV and CVC have two mora, so MAX-μ is satisfied, providing it applies at foot level rather than at syllable level. This type of analysis for reassigning the mora is discussed further in Hayes (1989).

(90) $\mu_1\ \mu_2$ $\qquad$ $\mu_1\mu_2$

CVCV	→	CVC

So our grammar so far is:

(91) *3μ , FTFORM(IAMB), MAX-μ » MAX V]$_{PP}$ » DEP-μ, PARSE-σ » MAX-V

FT-FORM IAMB is higher ranked than PARSE-σ because stray syllables are sometimes allowed as in (92). (93) shows us that the PARSE-σ also rules out several other candidates so that stray syllables can only survive at the right edge.

(92) kaskɔ 'bird'

kaskɔ	FTFORM(IAMB)	PARSE-σ
☞(kas)kɔ		*
(kaskɔ)	*!	

(93) kəsaananti 'brothers'

kasaananti	FTFORM(IAMB)	PARSE-σ
☞(kəsaa)(nan)ti		*
(kasaa)nanti		**!
ka(saa)(nan)ti		**!
kasaananti		****!
(kəsaa)(nanti)	*!	
(kəsaa)(nan)(ti)	*!	

This tableau doesn't quite complete the task as the candidate ka(saa)(nan)(tii) would at present do just as well as the winning candidate. Strays are only permitted at the right edge, so we need a constraint aligning feet to the left edge.

(94) ALL-FT-LEFT: Feet are aligned with the left edge of the word. (Kager 1999a)

(95)

kasaananti	PARSE-σ	ALL-FT-LEFT
☞(kəsaa)(nan)ti	*	**
ka(saa)(nan)(tii)	*	***!***

I now move on to cover the statement in (73iii) that - ∪ → (-) ∪ phrase-finally, leaving an unfooted syllable (no lengthening or deletion). In phrase-final position,

/CVVCV/ → (CVV)CV. So a failure to exhaustively parse the final syllable is considered better than lengthening. This result is achieved in the following tableau by ranking DEP-μ above PARSE-σ.

(96) /- ∪/ *input phrase-final*

/CVVCV/	FTFORM(IAMB)	DEP-μ	PARSE-σ
☞ (CVV)CV			*
(CVV)(CVV)		*!	
(CVV)(CV)	*!		

Moving on to (73iv), I find that I still need to rule out a sequence of two unfooted ∪ ∪ syllables. The obvious constraint to do this is PARSE-σ, but this constraint cannot be too highly ranked without forcing all syllables to be parsed, even at the right edge of the phrase. Unparsed syllables are permitted in Kera, so I need to find another constraint that will eliminate a ∪ ∪ sequence, but allow one unfooted syllable. The constraint to do this is *LAPSE as defined by Prince (1983). He describes 'clash' in terms of too-near adjacency of prominences and 'lapse' as the inverse of 'clash'. I will use this constraint here to avoid CVCV sequences being considered as the best option. *LAPSE has been defined in a number of ways by different linguists. Selkirk (1984) introduced the idea of 'lapse' to prevent a metrical foot from becoming too large, and to avoid adjacent syllables having stresses at the same height on the metrical grid. With the advent of Optimality Theory, this constraint became part of the OT inventory of constraints. Steriade (2000) uses the constraint to avoid strings of more than two stressless syllables. Zoll (2003) uses *LAPSE to avoid a sequence of two non-high tones on adjacent tone bearing units. Green and Kenstowicz (1995), and de Lacy (2004b) use a *LAPSE constraint to separate unstressed morae or syllables into two feet and to eliminate a candidate with an unfooted CVCV sequence. I will define it as follows, with no reference to foot structure.

(97) *LAPSE: Adjacent unstressed (i.e. light) syllables are not permitted

*LAPSE must be higher ranked than DEP-μ to avoid the CVCV non-footed sequence, as we see in (98):

(98) /∪ ∪/ *input, phrase final*

/CVCV/	*LAPSE	DEP-μ	PARSE-σ
☞ (CVCVV)		*	
(CVV)CV		*	*!
CVCV	*!		**

The following tableau combines the previous few tableaux to show the relative ranking of the constraints that we have discussed so far.

(99) /∪ ∪/ *input, phrase final - summary*

/CVCV/	FTFORM(IAMB)	MAX V]PP	*LAPSE	DEP-μ	PARSE-σ	MAX-V
☞ (CVCVV)				*		
(CVV)CV				*	*!	
CVCV			*!		**	
(CVC)		*!				*
(CVCV)	*!					

This tableau demonstrates the following grammar:

(100) FTFORM(IAMB), MAX V]PP, *LAPSE » DEP-μ » PARSE-σ » MAX-V

Where the vowel is already long, this grammar is sufficient to retain the long vowel. In this case, the vowel is not deleted, or shortened:

(101) /∪ -/ *input (all contexts)*

/CVCVV/	FTFORM(IAMB)	MAX-V
☞ (CVCVV)		
(CVC)		*
(CVVCV)	*!	
(CVCV)	*!	

Likewise, for the input /- -/, no vowel is shortened. The undominated constraint MAX-μ already rules out this possibility. In the following tableau, we can see that (CVCVV) is a well-formed foot, yet it is not chosen as it violates MAX-μ.

(102) /- -/ *input (all contexts)*

/CVVCVV/	MAX-μ
☞ (CVV)(CVV)	
(CVCVV)	*!

2.3.3 Constraints on phrase-medial position

The fifth statement from (73) which I need to cover is: (v) - ∪ # ∪ - → (-)(-)(∪ -), (vowel lengthening). Recall that this shows that the parsing at word level plays a role. Otherwise, we would expect the output for this input to be *(-)(∪ -)(-) where the two L syllables combine together. This doesn't happen because the second light syllable is already footed with the following syllable.

(103) /gɔldɛ kabaŋ/ 'search for wood'

→ (gɔ̀l)(dɛ̀:)(kə̀bàŋ)

Compare this with (73f) - ∪ # - → (-)(∪ -). Here there is no restriction on the light syllable joining the next syllable to form a foot, and no vowel lengthening is required.

(104) /saama mɔɔtɔŋ/ 'large rope'

→ (sāa)(mə̄mɔ́ɔ)(tɔ́ŋ)

For the - ∪ # ∪ - input, the constraints that I have already established are enough to deal with the less likely candidates:

(105) /- ∪ # ∪ -/ *input phrase-medial*

/CVVCV #CVCVC/	*3μ	MAX-μ	FTFORM(IAMB)
☞ (CVV)(CV:) #(CVCVC)			
(CVVCV:) #(CVCVC)			*!
(CVVCV) #(CVCVC)			*!
(CVCV:) #(CVCVC)		*!	
(CVVC) #(CVCVC)	*!		

There are however, a few candidates that still have to be eliminated: I must eliminate candidates that have unfooted material in phrase-medial position, and candidates that combine syllables to form a foot across the two words. *LAPSE will help in this respect. I also need another constraint that does not allow footing across prosodic word boundaries.

(106) ALIGN PRWD L: Every prosodic word begins with a foot. (ALIGN (PRWD L, FT L)) (Kager 1999a)

The motivation for this constraint comes from the strict layer hypothesis (Selkirk 1984, 1986). The next tableau deals with some candidates that were not eliminated in the previous tableau.

(107) /- ∪/ *input, non-phrase final, followed by* /∪ -/

/CVVCV #CVCVC/	*LAPSE	DEP-μ	PARSE-σ	ALIGN PRWD L
☞ (CVV)(CV:) #(CVCVC)		*		
(CVV)(CV#CV:)(CVC)		*		*!
(CVV)CV #(CVCVC)	*!		*	

The last candidate in (107) provides an argument for my formulation of *LAPSE as this constraint needs to be applied when the two CV syllables are not in the same foot.

The constraint ALIGN PRWD L must be ranked below PARSE-σ so that the word boundary can be crossed by the foot in other cases. In Kera, the input /- ∪ # - / gives the output (-)(∪ -), which violates the strict layer hypothesis. This can only happen when the syllable which links to the following syllable is unparsed at word level.

(108) /- ∪/ *input, non-phrase final, followed by* /-/

/CVVCV #CVC/	DEP-μ	PARSE-σ	ALIGN PRWD L
☞ (CVV)(CV#CVC)			*
(CVV)CV #(CVC)		*!	
(CVV)(CV:)#(CVC)	*!		

2.3.4 Non-footed epenthetic vowels

In section 2.2.10 we looked at various systems that might operate in polymorphemic words with a string of suffixes, each needing an epenthetic vowel. These systems can be described in an OT framework, and the analysis helps to show what separates the systems. Recall that system 1 involves ternary feet, e.g. (baa)(dətətan), system 2 has a final disyllabic foot with stray syllables allowed, e.g. (baa)da(tətan) and system 3 allows codas but avoids stray syllables, e.g. (baa)(dat)(tan). Of these three, 2 and 3 clearly exist for some speakers, but 1 may not be attested. We will come back to look at the differences between them shortly, but I will first establish what they have in common.

None of these systems have a lengthened epenthetic vowel although they can be heads:

(109) gɔl-ŋ > gòlɔ̀ŋ ɔ is epenthetic and also a head vowel

If it weren't for the fact that epenthetic vowels can be heads in Kera, I could use the constraint HEAD-DEP as developed by Alderete (1999b) and slightly redefined by Kager (1999b).

(110) HEAD-DEP: Every vowel in the output prosodic head has a correspondent in the input.

But in Kera, the epenthetic vowel can carry one mora. Note that these vowels are not underlying but they must be given a mora when they become a head vowel. If the syllable is made heavy by a coda consonant, then two moras are permitted in the syllable, but these vowels cannot be a head with two moras. So our constraint needs to avoid the addition of two moras to any vowel. Other vowels can of course be bimoraic, but as they presumably have one mora in the underlying form, they do not increase their mora count by two either. The constraint that I need is DEP μ^2. This constraint is a self-conjoined constraint in the style of Itô and Mester (1998). Their use of such constraints is based on the understanding that the multiple presence of certain constraints is worse than a double violation of a single constraint. In the case of Kera this means that in certain situations a violation of DEP μ is tolerated, but a violation of DEP μ^2 is not.

(111) DEP μ^2: No vowel can increase its mora count by two. (i.e. epenthetic vowels cannot be phonologically long)

I need to rule out syllabic consonants, although it should be noted that Kera does have a syllabic nasal in a few words, so presumably this constraint can be violated in those cases.

(112) HNUC: Syllable nuclei are maximally sonorous (i.e. no syllabic consonants). (Prince and Smolensky 1993)

These constraints rule out some of the possible candidates:

(113)

...k-t....	DEP μ^2	FTFORM(IAMB)	HNUC
-.kt.-			*!
☞-.kVt.-			
-.(kVtV).-		*!	
-.(kVtVV).-	*!		

Assuming that these constraints are undominated (apart from the syllabic nasal case which is not discussed here), I will not consider candidates which violate these.

To cover the systems used in long words, as discussed in §2.2.10, I need certain constraints that have already been discussed, namely: PARSE-σ, DEP V, FTFORM(IAMB) and also the following constraints:

(114) *CODA: No coda (Kager 1999a)

ALIGN FT R: Feet are aligned to the right edge of the word (Kager 1999a)

I will begin with system 2 (see (66)), as this is the system that I know is used. System 2 avoids codas where possible and it does not allow ternary feet. So baad-t-t-n > (baa)da(tətan). The grammar we need is:

(115) *CODA, FTFORM(IAMB) » PARSE-σ » DEP V, ALIGN FT R

The next tableau motivates *CODA » DEP V, also PARSE-σ » ALIGN FT R, and FTFORM(IAMB) » PARSE-σ

(116) *System 2*

baad-t-t-n	*CODA	DEP μ^2	FTFORM(IAMB)	PARSE-σ	DEP V	ALIGN FT R
☞(baa)da(tətan)	*			*	***	***
(baa)data(tan)	*			** !	***	***
(baa)(dətətan)	*		* !		***	***
(baa)(daa)(tətan)	*	*!			***	*****
(baa)(dat)(tan)	** !				**	***

(117) *System 2*

baad-t-t-n-u	*CODA	DEP μ^2	FTFORM(IAMB)	PARSE-σ	DEP V	ALIGN FT R
☞(bɨɨ)dutu(tunu:)				**	***	****
(bɨɨ)dututu(nu:)				***!	***	****
(bɨɨ)du(tutunu:)			* !	*	***	****
(bɨɨ)(dutuu)(tunu:)		*!			***	******
(bɨɨ)du(tut)(nu:)	* !			*	**	****
(bɨɨ)(dutut)(nu:)	* !				**	****
(bɨɨ)(dut)(tunu:)	* !				**	*****

System 3 avoids inserting epenthetic vowels where possible even though this results in more closed syllables, and it also has all syllables parsed where possible. The key difference is the ranking of *CODA and DEP V. The tableaux for this system are as follows.

(118) *System 3*

baad-t-t-n	DEP V	DEP μ^2	FTFORM(IAMB)	PARSE-σ	ALIGN FT R	*CODA
☞ (baa)(dat)(tan)	**				***	**
(baa)(daa)(tətan)	***!	*			*****	*
(baa)da(tətan)	***!			*	***	*
(baa)data(tan)	***!			**	***	*
(baa)(dətətan)	***!		*		***	*

(119) *System 3*

baad-t-t-n-u	DEP V	DEP μ^2	FTFORM(IAMB)	PARSE-σ	ALIGN FT R	*CODA
☞ (bɨɨ)(dutut)(nu:)	**				****	*
(bɨɨ)(dut)(tunu:)	**				*****!	*
(bɨɨ)du(tut)(nu:)	**			*!	****	*
(bɨɨ)(dutuu)(tunu:)	***!	*			******	
(bɨɨ)dutu(tunu:)	***!			**	****	
(bɨɨ)dututu(nu:)	***!			***	****	
(bɨɨ)du(tutunu:)	***!		*	*	****	

So the grammar for system 3 is DEP V, DEP μ^2, FTFORM(IAMB) » PARSE-σ, ALIGN FT R, *CODA

The other system that we considered was System 1, which allows ternary feet. This system, the reader will recall, may not be attested. For it to exist, PARSE-σ would have to be ranked above FTFORM(IAMB) so that all syllables are parsed into feet even if the resultant foot is not iambic. But I have established in (100) that the ranking for these two constraints must be the inverse of this in all dialects of Kera. So the grammar of Kera predicts that ternary feet will not be permitted. It would be a helpful line of research to check whether this prediction is true.

Space does not permit a full investigation into the typology of these systems, but the following observations can be made. Of the 6 constraints in the tableaux above, there are certain limitations already set by the grammar: DEP μ^2 is undominated. FTFORM(IAMB) must be above PARSE-σ. This would still leave us with a large number of combinations of

constraints to consider. However, if I assume that the candidates listed in (118) are the only reasonable candidates[19], I can find what ranking is necessary for each of them to win.

Firstly consider *(baa)(dat)(tan)*: This candidate will win if DEP V is the highest ranked of the remaining constraints (when DEP μ^2 is removed from the list), because all other candidates are immediately eliminated. We saw this happen in system 3. The ranking of the other constraints with respect to each other is then irrelevant (in both of the tableaux). This candidate will only lose if *CODA is ranked above DEP V. So now assuming this to be the case, we consider when the other candidates could win. We know that *(baa)(dətətan)* cannot win because of our previous discussion about ternary feet. Likewise *(baa)data(tan)* never wins because (baa)da(tətan) has less violations for every constraint. *(baa)(daa)(tətan)* also cannot win because it violates DEP μ^2. So the only remaining candidate is *(baa)da(tətan)* which is system 2.

By a similar logic for *baad-t-t-n-u*, if DEP V is highest, *(bʉ)(dutut)(nu:)* wins, and this is system 3. *(bʉ)dututu(nu:)* can't win because *(bʉ)dutu(tunu:)* always has fewer violations and *(bʉ)(dut)(tunu:)* can't win because *(bʉ)(dutut)(nu:)* has fewer violations for each constraint. *(bʉ)du(tutunu:)* can't win because of the ternary foot. *(bʉ)du(tut)(nu:)* can never win over *(bʉ)(dutut)(nu:)*, again because of a comparison of the violations for each constraint. So as before, we are left with the system 2 candidate: *(bʉ)dutu(tunu:)*.

So in both cases, we are essentially left with system 2 or 3. There may be the possibility of minor changes in the ranking, but the resultant outputs should be one of these two forms. This approach is not foolproof as there may be candidates that were not included in the tableaux. Certain rankings may still vary so there could be several possible grammars, but it looks as though there are only two possible outputs. The key constraints are DEP V and *CODA. If DEP V is highest ranked, we get system 3, if *CODA is highest ranked, we get system 2.

Note that *CODA probably only comes into play with epenthetic vowels. All Kera speakers have codas in lexical items, but in this case, high ranked faithfulness constraints would safeguard these words from any changes.

We have seen two possible outputs for these polymorphemic words and acknowledged that speakers differ in which they use. We predict that the ternary system is not possible in Kera, whereas systems 2 and 3 are both used regularly. In the rest of this thesis, words of the type discussed here are written according to the structure that was used by the speaker when the item was recorded. For words with one to three syllables, the systems all converge on one form. So *baad-n-m* must be parsed as *(baa)(dənam)*. For

[19] There is also the candidate *(baa)(dətaa)(tan)*, but as this violates DEP μ^2, it would not be a winning candidate under any system.

longer words, there are two ways of parsing them. System 2 gives *(baa)da(tɔtan)* and *(bɨɨ)dutu(tunu:)* while systems 3 and 4 give *(baa)(dat)(tan)* and *(bɨɨ)(dutut)(nu:)*.

We noted in section 2.2.10 that there is also a challenge in parsing multiple function words, even though they do not have epenthetic vowels.

(120) tɨ	bɨ	mɔ	-ŋ	'isn't it so?'	>	a. (tɨbɨmɔŋ)
emphasis	*of*	*question*	*def.art.*		or	b. tɨ(bɨmɔŋ)
					or	c. tɨbɨ(mɔŋ)

The following tableau shows how I can still ensure the right result. Assuming LEXWD = PRWD, function words do not lengthen while lexical words do and that Prosodic Words must contain a foot.

(121) tɨ bɨ mɔ-ŋ 'isn't it so?' *(all function words)*

tɨ bɨ mɔ-ŋ	LEXWD = PRWD	PRWD [FT]	DEP μ
☞ tɨ bɨ mɔŋ			
[tɨ bɨ mɔŋ]$_{PrWd}$		* !	
(tɨ bɨ:) (mɔŋ)			* !

(122) wɨ́ dī kán 'he draws water' *(dī kán are lexical words)*

wɨ dī kan	LEXWD = PRWD	PRWD [FT]	DEP μ
☞ (wɨ dī:) (kán)			*
[wɨ dī kán]$_{PrWd}$		* !	
wɨ dī kán	* !		

2.3.5 Summary

The analysis above shows us that we need a grammar as follows:

(123) PRWD [FT], *3μ, MAX- μ, PRWD = LEXWD » HNUC, DEP-μ^2, FTFORM (IAMB) » MAX-V_{PP}, *LAPSE » DEP-μ » ALIGN FT L, PARSE-σ » MAX-V, ALIGN PRWD L

This grammar gives us the following results:

(124)
(i) There are only (∪ -) and (-) feet
(ii) ∪ ∪ → - phrase-medially (vowel deletion) and ∪ - phrase-finally (vowel lengthening)
(iii) - ∪ → (-) ∪ phrase-finally, leaving an unfooted syllable (no lengthening or deletion)
(iv) No ∪ ∪ sequence (except for epenthetic vowels)
(v) - ∪ # ∪ - → (-)(-)(∪ -), (vowel lengthening)
(vi) - ∪ # - → (-)(∪ -)

2.4 Obstruent release

There is one more category of words with an apparent structure of CVCVCV. A closer examination shows us that these words all have a final –i vowel and that the consonant preceding this vowel is an obstruent or [l]. Note that in the words in (125), the first syllable has the vowel of a light syllable while the second has the vowel of a heavy syllable, so our first attempt at parsing would be either (CVCV)CV or (CVCVC)V. The first gives us a (CVCV) foot which we don't want and the second includes unconventional syllabification.

(125)	/saɓak/	→	[sə̄ɓāki]	'power'
	/paɗak/	→	[pə́ɗāki]	'light'
	/bɔbɔf/	→	[bɔ̀bɔ̀fi]	'yellow'

There is also a group with the output CVCi, as illustrated in (126). The quality of vowel in these words leads us to suppose that the parsing must be (CVC)V.

(126)	/kul/	→	[kūli]	'house'
	/kɔp/	→	[kɔ́pi]	'container'
	/hɔd/	→	[hɔ̀di]	'jar'

If the –i is part of the phonological structure of the word, then the whole basis of this chapter is in question because it looks like I would then have to concede to a (CVCV) foot.. However, because the –i appears if and only if an obstruent appears before it, I propose that we consider the –i to be a phonetic release following an obstruent to avoid having obstruents in word-final position. For this to be true, we must ascertain that there are no words ending in an obstruent and that there are also no words ending in a sonorant plus an [-i] vowel of this type. With the exception of ideophones plus one or two words ending in [-li] such as [kuli] shown above, both of these statements are true.

If we assume that the –i is a phonetic release and that it is therefore not present in the underlying form or in the parsing, we will have the following structures for the words above: /CVCVC/ and /CVC/.

(127) *Comparison of /CVCV/ and /CVC^{i}/ words*

/bɛgɛ/ 'animal'	/kɔp^{i}/ 'container'		
begɛŋ	kɔpiŋ/kɔpi/kɔppiŋ/kɔp	*With definite article*	
bɛg	kɔp	*Phrase medial*	
begɛ:	kɔpi	*Phrase final*	*kopi:

The /CVC^{i}/ words give the appearance of being /CVCV/ words like /bɛgɛ/, but in the /CVC^{i}/ words, the first V is a [-ATR] head vowel and it does not shorten. This leads to the conclusion that we should parse these words as (kɔp)^{i}, where the superscript –i does not exist in the phonological representation. The same approach can be used for the longer words with a parsing such as: (səɓak)^{i}. This parsing fits what we know about foot structure and the lengths and qualities of the vowels. In a comparison of 20 words of the form (CVC)^{i} and twenty words of the form (CVC), the mean vowel duration was 67 ms and 62 ms respectively. The significance test gave $p = 0.36$, so we cannot reject the null hypothesis that they are the same.

There is a complication with this analysis in that when a definite article -ŋ is added, the –i is then often treated as part of the phonological word with a possible refooting of the whole word, but there is considerable variation between speakers at this point and possibly between speech rates. There is also variation as to the duration of the –i. For this reason I cannot use these facts as major evidence for the foot without further research. It would take a study of many speakers to prove that the changes all conform to the Kera phonology. But we can say that there is a parsing which appears to match the quality and quantity measurements and which does not exclude the foot analysis as given earlier in this chapter.

If [i] were part of the phonology, the parsing of CVCi as (CVC)i and CVCVCi as (CVCVC)i would be unconventional as it either divides up the final syllable or implies unusual syllabification, going against the maximal onset principle (Ewen and v.d. Hulst 2001), where the final consonant must be in the same syllable as the -i that follows. Prince (1980), Selkirk (1984), Hayes (1995) and Blevins (1995) also insist that syllables cannot be divided by feet. Everett (1996), Wiltshire (2003), Kager (1995b) and Halle and Vergnaud (1987) entertain the possibility that in some languages, in certain circumstances, syllable integrity is a violable constraint, but in the Kera case, I do not have to argue against this principle because the parsing which separates off the final –i assumes that the –i does not exist in the phonological structure. It is just written for clarification. When the –i becomes

phonologized with the addition of -ŋ, the problem goes away because the parsing changes accordingly and the -i is included in the foot with no violation of the *(CVCV) constraint.

Other languages exist with similar final vowels following stops and nasals. Blevins (2004) describes some including: Talaud (Mills 1975a,b) where [a] occurs after stops and nasals, Dobel (Blevins and Garrett 1998) where an excrescent [u] occurs after word-final stops, and Kambera (Klamer 1994) where roots ending in consonants receive a [-u] which disappears in rapid speech. Blevins classifies these vowels as excrescent vowels, in a similar manner to the transitions described earlier. Blevins suggests the possibility that although excrescent vowels are historically present as a phonetic release from the obstruent, speakers may be at different points along a scale of phonologizing the phonetic feature.

(128) *Strategies for phonologizing the -i release following an obstruent in Kera*

/CVC$_{ob}$/ → (CV:)Ci
or → (CVC$_1$)C$_1$i
or some sort of combination of the two.

/CVCVC$_{ob}$/ → (CVCV:)Ci
or → (CVCVC$_1$)C$_1$i
or some sort of combination of the two.

To test this analysis, four Kera speakers were asked to choose the correct spelling for a list of approximately 100 words which included some words with a transition, some without and some with the final obstruent release –i. Many of the words included transitions, normal vowels and obstruent releases, all with [i] quality. Without exception, they chose to spell all of the CVC_CV(C) words as CVCCV(C) and all the /CVCVC$_{obstr.}$/ words as CVCVCi.[20] Their choices confirm the division of these words into the different types. At the end of this test, the same group of Kera speakers spontaneously discussed the -i appearing after obstruents identifying this -i as 'not really there'. One of them called it the 'phantom i'. He was able to identify this -i in other words such as kuli 'house'. The Kera still include this <i> in the orthography, but that may be due to the influence of non-Kera linguists who heard it and wrote it.

[20] They were not given the option of CVCV:Ci. But I did not get the impression that they perceive the second vowel as long. They were also not given the option of CVCVC without the i, but these were the only words where they allowed an apparent CVCVCV pattern to occur. For words with an /a/ vowel the spelling was CəCaCi which implies the parsing suggested here.

2.5 OT analysis of ATR allophones

In section 2.2.3.1, we looked at the question as to whether the allophones are really phonological vowels in complimentary distribution or if they are all one vowel with varying amounts of undershoot based on the duration of the vowel. The answer to this question is not altogether clear. It may be that the variation started as undershoot and that the allophones have since become phonologized. For this reason, it is difficult to tease these options apart. But in this thesis, I will continue to treat them as allophones. I now briefly discuss what kind of OT grammar would be needed if we take the allophones to be phonological entities.

We will consider constraints similar to those proposed by de Lacy (2002b) for the relationship between tone and feet, shown below. De Lacy focuses on the tendency for high tones to be found in stressed syllables and low tones in non stressed. His grammar is:

(129) *HD/LO» *HD/M » *HD/H and *NONHD/H » *NONHD/M » *NONHD/L

In Kera, -ATR non-high vowels are found in heads, +ATR non-high vowels are found in non-heads. This implies the following constraints and grammar:

(130) *NONHD/-ATR: Non-head vowels are not -ATR
*NONHD/+ATR: Non-head vowels are not +ATR
*HD/+ATR: Head vowels are not +ATR
*HD/-ATR: Head vowels are not -ATR[21]

*NonHd/-ATR » *NonHd/ATR and *Hd/+ATR » *Hd/-ATR[22]

For the following examples, the head vowel is underlined.

(131) cəwa: 'sun'

cawa	*NONHD/-ATR	*NONHD/+ATR	IDENT V
☞(cəwa:)		*	*
(cəwə:)		*	**!
(cawa:)	*!		

[21] De Lacy claims that his tone constraints are universal. It would be an interesting topic for research to determine how universal these ATR/Feet constraints are.

[22] This grammar would be a logical conclusion from the observations of de Lacy (2002) that stressed mid-vowels are more marked than stressed low-vowels.

(132) tosɔ: 'sore'

toso	*HD/+ATR	*HD/-ATR	IDENT V
☞(tosɔ:)		*	*
(tɔsɔ:)		*	**!
(toso:)	*!		

These constraints cover the three non-high vowels, but /i/ and /u/ do not have [ɪ] and [ʊ] as allophones, so we need to avoid -ATR high vowels. This can be covered by a high ranking constraint: *+hi,-ATR

(133) *+hi,-ATR: Non-high vowels have the feature [+ATR]

2.6 Conclusion

The main evidence that Kera has iambic feet comes from the deletion and lengthening of vowels to avoid the badly-formed (CVCV) foot. The claim is further supported by the choice of vowel allophones and the duration of heads and non-heads, together with the extra intensity on head vowels. In addition, the vowel harmony and tone spreading domains suggest that the foot is an important structure in Kera. The fact that all lexical words are minimally bimoraic also supports the case. Finally, we have seen that the foot is psychologically real for Kera speakers. We therefore conclude that the iambic foot is important in several areas of Kera phonology.

We have seen that an unfooted light ('stray') syllable at the right edge of the phrase is allowed in Kera. This has supported our case for the existence of the foot because any account that tries to discount the foot would have to explain why these syllables behave differently from underlying CV syllables become heads of feet. The heads lengthen whereas the stray syllables do not. Parsing appears to take place initially at word level with some adjustments at phrase level on stray syllables, but the parsing at phrase level does not reparse syllables which are already part of feet at the word level. Function words which are not bimoraic generally cliticize to a following word and become part of the next foot. Epenthetic vowels cannot be bimoraic, but they can be head vowels. Both epenthetic vowels and function words can be included in feet, but they may at times be unfooted if this is unavoidable.

We have not investigated the effects of intonation on duration and quality, but we have observed that there is extra phonetic lengthening at the right edge of the utterance. This lengthening does not occur at the end of phonological phrases.

Within the framework of Optimality Theory, the key constraints are FTFORM (IAMB) and *LAPSE. These combine with other constraints to eliminate a light-light output.

The constraint ranking that I have developed adequately covers the various strategies employed to avoid a CVCV sequence.

We have also looked briefly at the evidence for feet in other Chadic languages. We know that several Chadic languages are quantity sensitive and show some signs of having feet. But there are plenty of opportunities for more research into the foot structure of these languages. It is unlikely that Kera is the only language from this language group that makes such use of the foot structure.

Kera is unusual in being an example of an iambic language where stress has no role to play in the parsing of feet. The analysis involving feet has given us an explanation for the shortening, lengthening and deletion of certain vowels. Feet also have a part to play in Kera vowel harmony and in the domain of tone spreading (as we will see in the following chapters). The foot structure is therefore a central part of the phonology of Kera.

Chapter 3
Vowel harmony and foot interaction

3.1 Introduction

This chapter examines a complex system of vowel harmony (Ebert 1974, Kenstowicz and Kisseberth 1979 (pp.383-384), Harris 2003, Pearce 2003) that has implications for the domains within which harmony may operate, and particularly gives further evidence of the importance of the foot in Kera. We will consider the theoretical issues that are relevant to vowel harmony systems, and each of the types of vowel harmony will be analysed within the framework of Optimality Theory, with particular emphasis on the role of the foot.

Vowel harmony is the name given to a system where all vowels agree for one of their properties within a specific domain, which is usually said to be the Prosodic Word (van der Hulst & van de Weijer 1995). Archangeli and Pulleyblank (2007) identify the issues involved in harmony as the following: There is a need to define the triggers and target conditions, the domains involved, the direction of harmony, whether there is iteration and the locality of harmony. They note that in many languages harmony can be restricted by some height condition on the trigger or target or both. The types of features that are generally spread in vowel harmony processes are [high], [low], [back], [round], ATR and RTR. In addition there are certain manner features that can spread such as nasal or r-colour. Any given language can spread one or a number of these features. If all vowels within a domain are identical, this is described as total harmony. Although the domain of harmony is often the Prosodic Word, it can also be the syllable as seen in Yoruba nasal harmony, the root as seen in Tiv verb roots, the Morphological Word as in Turkish rounding and back harmony, and within feet as in Ascrea Italian (Archangeli and Pulleyblank 2007).

Like Turkish, Kera has fronting and rounding harmony, but it also has height harmony and total harmony. These operate over different domains, including the iambic foot and the Prosodic Word, which consists of all of the footed material within the Morphological Word. Suffixes are always footed and therefore part of the Prosodic Word, but Kera also has unfooted syllables at the right edge of words. These do not undergo any kind of harmony other than height harmony. For most of the harmony types, features spread from right-to-left, but height harmony is of particular interest because it is bi-directional with height dominance. We will also look at epenthesis in this section because although feature-filling is not the same as vowel harmony, there are similar surface patterns in Kera and the same constraints are adopted.

We will consider the following types of harmony and spreading:

a. **Epenthesis with total "harmony"**. This is a feature-filling process with the Prosodic Word as domain. When there is more than one specified vowel which could supply the features the preferred direction of spreading is right-to-left. Feet are marked with parentheses and epenthetic vowels are underlined.

(1)	mirk-t-n > (mīr)(kīīn)	'greets me repeatedly'	(One underlying vowel)
	mirk-t-u > (mír)(kútú:)	'greets him repeatedly'	(Right-to-left preferred)
	mirk-t-n-u > (mír)(kút)(nú:)	'greeted him repeatedly'	(Beyond foot boundary)

b. **Height**. This harmony exhibits height dominance in both directions with the Morphological Word as the domain of spreading.

(2)	mirk-a > (mír)(kí:)	'greet her (3sf)'	(Left-to-right)
	baad-u > (bɨɨ)(dù:)	'wash him (3sm)'	(Right-to-left)

c. **Fronting and rounding**. An underlying high central vowel will be fronted or rounded by an underlying high front or high round vowel within the Prosodic Word, spreading from right-to-left. This type of harmony involves Parasitic Harmony somewhat like that found in Yawelmani Yokuts (Cole and Kissebirth 1998) and Kàlɔŋ (Hyman 2003), with the restriction that the trigger and target must both be underlyingly high. Parasitic harmony is defined as harmony for a feature F which only applies across segments X and Y if X and Y share the same value for another feature G. Hyman (2001b) describes a similar kind of parasitic harmony in Gunu where rounding harmony only occurs for underlyingly low vowels. Height harmony also takes place in Gunu, but vowels which become high through height harmony are excluded from the parasitic rounding harmony. (3) shows how Parasitic Harmony works for Kera.

(3) cɨɨr-i > (cīi)(rī:) 'your (f) head' cɨɨr-u > (cúu)(rú:) 'his head'
ɨsk-i > (īs)(kī:) 'hear you (f)' ɨsk-u > (ús)(kú:) 'hear him'
but no fronting or rounding harmony if the trigger is not underlyingly high:
ɨsk-ɛ > (ɨs)(kī:) 'hear' vɨɨg-ɛ > (vɨɨ)(gī:) 'is emptying'
and no fronting or rounding harmony if the target is not underlyingly high:
baad-i > (bɨɨ)(dī:) 'wash you (f)' * (bii)(di:)

d. **Fronting**. This harmony targets central vowels and is triggered by any front vowel. Spreading only takes place within the foot, from right-to-left. In (4), a root with a central vowel that ends with one consonant forms one foot with the suffix included, and this results

in fronting harmony taking place. But roots with central vowels ending in two consonants (or with one consonant plus a consonant suffix) cannot form one foot with the suffix and therefore, this type of harmony does not take place.

(4)	ɨs-ɛ > (ɪ̂sɪ̄:)	'sit down'	
	bɨŋ-ɛ > (bɪ̌ŋɪ̌:)	'open'	
	fal-ɛ > (fɛ́lɛ́:)	'find'	
vs.	ɨsk-ɛ > (ɪ̂s)(kɪ̂:)	'sit you (f) down'	*(is)(ki:)
	fal-t-ɛ > (fál)(tɛ́:)	'find (hab.)'	*(fɛl)(tɛ:)

e. **Total**. This kind of harmony involves a copy of all features. The domain of total harmony is the Prosodic Word, within the stem.

(5)	(kūŋ)(kūrūŋ)	'leather bag'	*(kuŋ)(kiriŋ)
	(dɨ̌bɨ̌ɨ)(bɨ̌r)	'lizard'	*(dɨbɨɨ)(bir)
	(kɛ̄f)(tɛ̄r)	'book'	*(kɛf)(tir)
	(káa)(sáw)	'millet'	*(kaa)(siw)
	(kɔ̄ɔ)(mɔ̄m)	'rat'	*(kɔɔ)(mam)
	(fɪ̄lɪ̂i)(lɪ̂w)	'hole in gourd'	*(filii)(lew)

Non-footed syllables are exempt:

(gɪ̌dɪ̂i)rɨ̌	'tribe, species'	*(gidɨɨ)rɨ
(kɨ̄kɨ̄:)ɓā	'peace, cold'	*(kɨkɔɔ)ɓa
(kúpúr)kɪ̂	'billy goat'	*(kupir)ki
(cēcɛ̄r)kɨ̄	'vertebrae'	*(cecɨr)kɨ
(gə̀dàa)mɔ́	'horse'	*(gədɔɔ)mɔ
(dògə̀y)nà	'present time'	*(dogay)na

Suffixes are also exempt from being triggers or targets in total harmony.

The right-to-left direction of spreading in most of these harmony types may be caused by the need to identify vowel suffixes which consist of only one vowel (see §3.5 and §3.6 for more discussion on the motivation and direction of harmony). Suffixes can trigger most types of harmony, but they can only be targets of height harmony. While height harmony involves little information loss, the changes from fronting and rounding are more severe.

Kera harmony is of interest because of the varying combinations of harmony types, domains and directions. In addition, height dominance and the foot domain are both rare

and therefore fill typological gaps. (Archangeli and Pulleyblank 2007, van der Hulst & van de Weijer 1995). I will combine all of these seemingly incompatible strands within an OT framework and conclude that while the harmony system reduces the information load, it also has the function of defining the prosodic and morphological boundaries and thereby eases the task of parsing the speech signal.

In order to analyze the vowel harmony facts, we will need to recall that the allophones of the three non-high vowels that are present in heads of feet are [ɛ, a, ɔ]. These carry the feature [-ATR]. In the non-head position of a disyllabic foot, the [+ATR] allophones [e, ə, o] are found. The three high vowels [i, ɨ, u] do not have alternates. When there is total harmony in a word with disyllabic feet, the two corresponding allophones will appear in the same word. This means that the following combinations of vowels in a word are still counted as total harmony:

(6) e / ɛ ə / a o / ɔ
(with the first vowel in non-head position and the second vowel in head position).

The structure of this chapter is as follows. In §3.2, I will briefly describe the types of harmony, with examples, and then give a reminder of the relevant morphology which we will need to understand the vowel harmony processes. In §3.3 we will look at how the domains of vowel harmony fit in the prosodic hierarchy and consider the relationship between vowel harmony and the foot, with a detailed discussion of non-footed syllables. In §3.4 we look in detail at the Kera vowel harmony system, including an OT analysis for each type of harmony. In §3.5, we look at issues that arise from empirical measurements. These measurements confirm that the vowel harmony is really phonological and not merely co-articulation. They also lead us towards a possible motivation for vowel harmony in Kera and they show us the importance of the foot as a vowel harmony domain (In §3.6). Finally in §3.7, we consider the literature on vowel harmony in other Chadic languages and compare these with what we have found in Kera.

3.2. Summary of types of harmony

The following table gives a description of each type of harmony for comparison.

(7)

Harmony	Direction	Target	Trigger	Domain
Epenthetic feature-filling	← if possible	epenthetic V	underlying V	PrWd
Height	↔	all V	high V	MWd
Fronting and rounding	←	high central V	high fr/rd (suffix) V	PrWd
Fronting	←	central V	front (suffix) V	Foot
Total	←	all V (not suffix)	last head V (not suffix)	PrWd

3.2.1 Epenthesis

When consonantal affixes are added to a word, an epenthetic vowel is often required to avoid super-heavy syllables (such as CVVC or CVCC) or complex onsets. This vowel is a copy of the root vowel[1]. Archangeli (1984, 1988) and Pulleyblank (1986, 1988) call this kind of vowel a 'null segment'. These segments carry full specifications on the surface, but they behave phonologically as if they lack features. The quality of the vowel is not found in the underlying form and appears to be inserted later. This vowel undergoes vowel harmony, but cannot trigger it. However, in Kera, this vowel can be in the head position of a foot. It never lengthens, but in a closed syllable, it carries a mora. Hall (2006) discusses the attributes of epenthetic vowels, contrasting them with transitional vowels. Kera has both, and this may be the reason why the epenthetic vowel carries a mora, as it differentiates it from a transitional vowel which has no place in the phonology. She notes that the epenthetic vowel can be a copy vowel, which is the case in Kera. She also notes that the epenthetic vowel repairs a structure which is cross-linguistically rare. In some languages, this does not imply the presence of a mora, but in Kera, this is the analysis which works best. However, the epenthetic vowel is restricted to one mora only.

Epenthesis occurs in Kera in order to avoid consonant clusters in the onset or coda, so for example /CVC-C/ will have a surface form of CVCVC. The epenthetic vowel has no underlying features, so features must be given to this vowel from somewhere. If there is only one specified vowel in the word, the epenthetic vowel will take on the same features. (8) shows this process, filling in features from left-to-right. Foot structure is indicated with

[1] We will see later that if the word has a suffix vowel, the epenthetic vowel will copy the features of the suffix vowel, not the root vowel. For example wɨɨt-n-u > (wɨɨ)(tunu:).

parentheses although in this case it has no bearing on the quality of the epenthetic vowel. The epenthetic vowel is underlined.

(8) *Verbs with imperfective ø + 1 ps sg -n*

root	ø + -n 'is ... me'
i mirk- 'to greet'	(mīr)(kī̱n) 'is greeting me'
ɨ wɨt- 'to hit'	(wɨ̄ɨ̱n)
u buus- 'to divorce'	(bùu)(sù̱n)
ɔ gol- 'to look'	(gòlɔ̱n)
a baad- 'to wash'	(bàa)(dà̱n)
e jɛɛr- 'to write'	(jɛ̀ɛ)(rɛ̱̀n)

This process also works for multiple epenthetic vowels in longer words such as *mirk-t-n-m* > *(mīr)(kīt)(nīm)* 'greeted you (m. habitual)'. The features can also be filled in from right-to-left where there is a prefix, as shown in (9).

(9)	k-mirwi	>	(kɨ̱mɨ̂r)wɨ̂	'new m.'
	k-sarka-ŋ	>	(ká̱sár)(káŋ)	'black pl.'
	k-tɛŋka-w	>	(kɛ̱̄tɛ̱̄ŋ)(kɛ́w)	'mill stone pl.'
	k-pɨrki-w	>	(kɨ̱pɨ̄r)(kɨ́w)	'mountains'

This will be discussed further in §3.2.6. In the plural form where all syllables are footed, all of the vowels are part of the Prosodic Word and they are therefore subject to harmony processes. At this point I will focus on the prefix. So far, our evidence tells us nothing about the directionality of the filling-in process because the epenthetic vowel must have specified features, and there is only one vowel in the word to choose from.[2]

However, the feature-filling also takes place when there is a root vowel and a different suffix vowel. In this case there is a choice as to which features are used for the epenthetic vowel. In Kera, the features that are used come from the suffix, so the preferred direction of feature filling is right-to-left.

[2] The deletion of the second vowel in the last two examples of (9) will be discussed in §3.2.6. At word level these are stray vowels and are therefore are the first to be deleted, rather than the footed root vowel.

(10)	mirk-t-u	>	(mír)(kú̱tú:)	'greeted him (habitual)'
	gɔld-t-ɛ	>	(gɔ̀l)(dé̱té:)	'search (habitual)'
	baad-t-ɛ	>	(bàa)(dé̱té:)	'wash (habitual)'
	lɛnt-t-a	>	(lén)(tə̱tá:)	'lose her (habitual)'
	ɪsk-t-ɛ	>	(ɪ̄s)(kī̱tí:)	'hear (habitual)' (with height harmony)
	lugd-t-i	>	(lùg)(dɪ̱tí:)	'curse you (f) (habitual)'

From these examples, we might try to claim that the feature filling is affected by the foot structure, with the fill-in features taken from the vowel in the same foot. As the foot is the domain in certain types of vowel harmony, this would be a reasonable hypothesis, and it works for the majority of cases. However, we see in the following examples that when the word has more than two feet, the features still spread from right-to-left beyond the foot boundary.

(11)	mirk-t-n-u	>	(mīr)(kū̱t)(nū:)	'greeted him (habitual)'
	gɔld-t-n-i	>	(gùl)(dɪ̀t)(nì:)	'searched you (f. habitual)'
	baad-t-n-u	>	(bàa)(dù̱t)(nù:)	'washed him (habitual)'
	lɛnt-t-n-a	>	(lén)(tá̱t)(ná:)	'lost her (habitual)'
	ɪsk-t-n-u	>	(ɪ̄s)(kū̱t)(nū:)	'heard him (habitual)'
	lugd-t-n-a	>	(lùg)(dɪ̱tɪ̱:)	'cursed her (habitual)' (height harmony)

The maximum number of vowels that are specified in any word (except compounds and loans) is two, one of which will be the root vowel and the other a word-final suffix. So I have covered all cases of feature-filling. We have seen that if there is only one underlying vowel, the epenthetic vowel will have the same features. If there are two underlying vowels, the features of the epenthetic vowel will match the features of the vowel at the right edge of the word, which in every case is the suffix vowel. From these examples, and in order to be consistent with other types of harmony, I will take the domain of the filling-in process to be the Prosodic Word where the Prosodic Word includes all footed material within the word, but excludes non-footed material. The boundaries of the foot do not affect this process.

3.2.2 Height harmony

Height harmony is applied to polymorphemic words. [+high] is dominant, and if it appears anywhere, all vowels within the morphological word become [+high]. In the table below, the suffix undergoes height harmony in the first three lines, where the root vowel is high.

(12) *Imperfective with suffix -ɛ, raised by high root vowel*

root	-ɛ imperfective
i mirk- 'to greet'	(mîr)(kí:) 'is greeting'
ɨ vɨ:g- 'to empty'	(vɨ̌:)(gí:)
u tu:k- 'to arrive'	(tú:)(kí:)
ɔ gɔld- 'to search'	(gɔ̀l)(dɛ́:)
a ba:d- 'to wash'	(bà:)(dɛ́:)
ɛ jɛ:r- 'to write'	(jɛ̀:)(rɛ̀:)

In the following table of inalienable nouns with possessive suffixes, we not only see the -a suffix raised to -ɨ by high root vowels, but also non-high root vowels raised to high vowels by the high suffixes -i and -u. This implies bi-directional spreading and demonstrates that the height harmony is not directional or root dominant, but feature dominant: A high vowel in any position will cause all vowels to be high.

(13) *Inalienable nouns with -i, -u and -a possessive suffixes.*

root	-a (3fs) 'her....'	-i (2fs) 'your (f)...'	-u (3ms) 'his....'
i giid- 'stomach'	(gǐi)(dí:)	(gǐi)(dí:)	(gǐi)(dú:)
ɨ cɨɨ(r-) 'head'	(cɨ́ɨ)(rɨ́:)	(cɨ̄i)(rɨ̄:)[3]	(cúu)(rú:)
u guud- 'behind'	(gùu)(dí:)	(gùu)(dí:)	(gùu)(dú:)
a kaas- 'hand'	(káa)(sá:)	(kɨ̄ɨ)(sɨ̄:)	(kɨ́ɨ)(sú:)
ɔ dɔrd- 'voice'	(dɔ̀r)(dá:)	(dùr)(dí:)	(dùr)(dú:)
ɛ sɛɛn- 'brother'	(sɛ́ɛ)(ná:)	(sɨ̄i)(nɨ̄:)	(sɨ́i)(nú:)

The same process can be seen in imperative verbs with object suffixes.

(14) Verbs in the imperative with -i, -a, -u object suffixes

root	-a (3fs) '...her'	-i/-y (2fs) '...you(f)'	-u (3ms) '...him'
i mirk- 'to greet'	(mîr)(kɨ́:)	(mɨ̄r)(kɨ̄:)	(mîr)(kú:)
ɨ wɨt- 'to hit'	(wɨ̂tɨ́:)	(wɨ̄tɨ̄y)	(wútú:)
u gun- 'to wake'	(gùnɨ̀:)	(gùnɨ̀:)	(gùnù:)
ɔ gɔld- 'to search'	(gɔ̀l)(dá:)	(gùl)(dùy)	(gùl)(dú:)
a baad- 'to wash'	(bàa)(dá:)	(bɨ̀ɨ)(dɨy)	(bɨ̀ɨ)(dú:)
ɛ jɛɛr- 'to write'	(jɛ̀ɛ)(rà:)	(jɨ̀i)(rɨ̀:)	(jɨ̀i)(rù:)

[3] The [ɨ] root vowel also undergoes fronting and rounding in this table. The facts for fronting and rounding will be addressed in the next section.

The following table summarizes the examples above, showing that height harmony takes place in both directions

(15) Height harmony in both directions

[+hi] root + [+hi] suffix		[+hi] root + [- hi] suffix	
/giid+i/	(gii)(di :)	/giid+a/	(gii)(dɨ:)
/giid+u/	(gii)(du :)	/mirk+ɛ/	(mir)(ki:)
/cɨɨr-i/	(cii)(ri:)	/tuuk+ɛ/	(tuu)(ki:)
/cɨɨr-u/	(cuu)(ru:)	/vɨɨg-ɛ/	(vɨɨ)(gi:)
/guud+i/	(guu)(di:)		
/guud+u/	(guu)(du:)		
[- hi] root + [+hi] suffix		[- hi] root + [- hi] suffix	
/gɔld+i/	(gul)(duy)	/gɔld+a/	(gɔl)(da:)
/gɔld+u/	(gul)(du:)	/jɛɛr+a/	(jɛɛ)(ra:)
/baad+i/	(bɨɨ)(di:)	/baad+ɛ/	(baa)(dɛ:)
/baad+u/	(bɨɨ)(du:)		
/jɛɛr+i/	(jii)(ri:)		
/jɛɛr+u/	(jii)(ru:)		

Together these examples show that height harmony is bidirectional and that the triggers and targets can be suffixes or root vowels. This is the only type of harmony where suffixes can be targets. I will return to discuss possible reasons for this later on (see §3.6). The examples in (14-15) above show that the length of the word and the number of feet make no difference to the harmony. Epenthetic vowels are included in the process. So we get *mirk-t-n-a > (mir)(kɨt)(nɨ:)* 'greeted her (habitual)'. Height-dominant systems were previously unknown (van der Hulst & van de Weijer 1995), so this fills a typological gap.

To establish the domain of height harmony, we must consider monomorphemic words with stray syllables. There are many words where all vowels agree in height. The question is whether such words involve harmony, or simply arise naturally by chance.

(16)	(gǐđii)rɨ	'tribe, species'	(dògɔ̀y)nà	'present time'
	(kúpúr)kî	'billy goat'	(gə̀dàa)mɔ́	'horse'
	(hɨ̀n)jí	'snake'	(tɛ́w)ká	'type of tree'

There are also a few words which are disharmonic for height.

(17)	(dĩr)gɔ̀	'knitted jumper'	(bàa)dù	'cat'
	(kīkīɨ)bā	'peace, cold'	(cēcēr)kī	'vertebrae'

These appear to be less common. To quantify this, we will examine the expected frequency for such words compared to the observed frequency. In an examination of 380 words with stray syllables, the following table shows the ratio of observed/expected frequency. In cells where no items were observed, two figures are noted. The second is 0, but the first is the value for the ratio if just one item had been observed for that combination. This is so that we do not over-react to a 0 value in cells where the expected number would also be low.

(18)

O/E stray / root	i	ɨ	u	ɛ	a	ɔ
i	2.5	2	1	0.2/0	0.5	0.3/0
ɨ	1.5	4.5	2	0.1/0	0.2	0.2/0
u	3	0.2/0	3	0.4	0.4	0.3/0
ɛ	0.1	0.1/0	0.4/0	3	0.8	0.2/0
a	0.1	0.2	0.5	0.7	2	0.5
ɔ	0.3	0.1/0	0.2/0	1.2	0.7	5.5

In this table, a value close to 1 indicates that there is unlikely to be any harmony process affecting this result. A higher figure suggests that this combination could be harmonic and a lower figure suggests that this combination could be disharmonic. For the issue of height harmony, we are interested in the 4 quadrants marked by the thick lines. We can see clearly that the top left and bottom right quadrants involve higher numbers, and that supports the hypothesis that some height harmony is taking place in strays. However, this is not as convincing as I would like. Some of the numbers in these quadrants are below 1 suggesting that they are disharmonic combinations. A closer inspection reveals that the highest numbers which are really significant are the shaded numbers on the diagonal. These are the boxes which indicate total harmony. It is clear from these that a number of stray syllables do have a vowel that matches the root vowel and that this is above the amount expected if there was no harmony. So some stray syllables do undergo total harmony, although it is also clear that a large number do not. If this case were to be removed from the table above, we would be left with the table in (19).

(19)

O/E stray / root	i	ɨ	u	ɛ	a	ɔ
i		3	1.5	0.1/0	0.8	0.2/0
ɨ	2		3	0	0.4	0.1/0
u	4	0.1/0		0.5	0.5	0.1/0
ɛ	0.2	0.1/0	0.2/0		1	0.1/0
a	0.1	0.2	0.5	1		1
ɔ	0.3	0.1/0	0.1/0	2	1	

206 of the words in table (18) are compatible with a total harmony claim. This leaves 173 words with non-total harmony. Of these, 34 have disharmony in terms of height harmony. That means 34 words out of 380 (9%) do not fit the claim that height harmony takes place in stray syllables. This does suggest that there is some evidence of height harmony. In addition, looking at the table in (19), we see that the top left quadrant has the highest numbers and the bottom left and top right quadrant have the lowest. This is what I would expect with height harmony if [+high] is dominant as the harmony would drain the disharmonic quadrants in favour of the top left quadrant. Whereas I would expect the bottom right quadrant to stay with a value of around 1. A chi test on the results that generated this table confirms that the difference is significant with $p \leq 0.001$. However, there are still 34 cases for us to discount.

From these results, we could move in two directions.

(i) Assume that the disharmonic words are exceptions (possibly from loan words) and that height harmony therefore covers the whole of the Morphological Word regardless of the foot structure.

(ii) Assume that there are enough counter examples to show that height harmony is not operating on strays in any consistent way and that the domain of height harmony is therefore the Prosodic Word, with stray syllables excluded from the harmony.

The first position is plausible because at least some of these words are definitely loans. For example, from the list in (17), *(dir)gɔ* and *(baa)du* are known to be loans and *(kɨkɨ)ba* has another form *(kəkab)i* both of which might be variants of a loan.

The second position is harder to defend in that it would be unusual for a bi-directional, feature dominant system to be aware of foot structure. I realize that both claims could be defended, but on balance, I propose that we consider the domain to be the Morphological Word, and account for the cases where height harmony doesn't take place as exceptions which are mostly loans. This means that height harmony has a different domain from the other types of harmony, and that it does not observe the foot structure.

Before leaving height harmony, one more observation should be made. The dominant height harmony as found in Kera is a problem for some theories concerning vowels, in particular Element Theory (Harris 1994a). This theory deals with height harmony by referring to the presence or absence of the element [A] (which is effectively [-high] in other theories). Rennison (1990) claims that "no harmony element will ever involve subtraction", meaning that harmony cannot be the result of an element being disassociated. The theory predicts that dominant height harmony should not exist because it would involve the subtraction of [A] if [A] is not present elsewhere. Harris and Lindsey (1995) are aware of the problem that dominant height harmony poses for the theory and John Harris (1994b, 2003, p.c.) and Pearce (2003) acknowledge the difficulty of the Kera case. Harris proposes a licensing constraint: Within a word, [A] in one position must be licensed by [A] in another. This doesn't quite cover all the cases because potentially there could be two low vowels and one high vowel. This licensing constraint would then allow the two low vowels to remain whereas in reality all of the vowels become high. I am not aware of any other language that has dominant height harmony and Bakovic (2000) in his dissertation on harmony and dominance does not list any, so at this moment in time it is just one language which goes against the theory versus many other languages which support the predictions of the theory. For this reason, I would not wish to dismiss the whole theory on the basis of one language, but it does mean that our analysis needs a framework where this aspect is not a problem. Any theory that allows [+high] to spread will not have a problem with Kera, although it may have the larger problem of explaining why Kera is the only language found to date with this kind of dominance.

3.2.3 Fronting/Rounding harmony

There are two different situations in which fronting occurs. I deal with the first here. In this process, the high central vowel [ɨ] is fronted or rounded by the high suffixes [i] and [u] respectively. For this process to take place, both vowels must be underlyingly high.

(20)	fronting or rounding		no fronting or rounding	
	ɨsk-i > (ɨ̱s)(kī:)	'hear you (f)'	vs. ɨsk-ɛ > (ɨ̱s)(kí:)	'hear'
	cɨɨr-i > (cī:)(rī:)	'your (f) head'	vs. vɨɨg-ɛ > (vɨ̌ɨ)(gí:)	'is emptying'
	cɨɨr-u > (cú:)(rú:)	'his head'	vs. baad-u > (bɨ̌ɨ)(dú:)	'wash him'

(20) shows that both vowels must be underlyingly high. The examples on the right have surface high vowels, but the underlying form of the suffix -ɛ does not carry the feature [+high]; therefore no fronting or rounding takes place. This kind of harmony is known as Parasitic Harmony because harmony only takes place if the two segments have another

feature in common. Steriade (1981) and Kaun (1995) have noted that, in general, rounding harmony is favoured when the trigger and targets are both high, or failing that, when the target is high.

Examples like the first two on the right in (20) are very rare, so there is a question as to how much these are just exceptions, although there are no counter examples where the -ɛ suffix does trigger fronting. Examples like *baad-u* are not rare, where a non-high target does not undergo rounding.

Only the central vowel /ɨ/ can be a target. We do not find /i/ or /u/ rounding or fronting respectively.

(21)	mirk-u > (mír)(kú:)	'greet him'	*mirki	*murku
	buus-i > (bùu)(sì:)	'divorce you (f)'	*buusu	*biisi

There are no /-ɨ/ suffixes so we cannot test if the process works both ways in polymorphemic words. In monomorphemic words we can use the table in (19) to check if this kind of harmony is taking place between root vowels and stray syllables. If it is, I would expect the number for ɨ/u and ɨ/i to be low, while (in (18)) the i/i and u/u numbers should be very high. This is clearly not the case. There are in fact a number of words with stray syllables that show that this kind of fronting is not taking place.

(22)	(gǐɗii)rɨ̌	'tribe, species'	*(gidii)ri
	(hɨ̌n)jí	'snake'	*(hin)ji
	(bɨ̌ɨ)bú	'nursery for millet'	*buubu

These examples imply that this type of harmony is not applied to stray syllables, either as triggers or targets.

Harris (1994b, 2003) notes that there appears to be a paradox with the high central vowel in Kera. In the cases shown here, the vowel appears to be recessive, attracting the melody from other high vowels within the Prosodic Word, and giving the impression that it is maximally underspecified. But in height harmony, as we have seen in §3.2.2, this same vowel can trigger height harmony as in */vɨig-ɛ/ > (vɨi)(gi:)* 'empty/forgive'. In this case the high central vowel appears to be dominant and specified for [+high]. I will discuss how this vowel can be analysed in §3.3.2, but I note here that the paradox exists.

In summary, fronting and rounding occur on the high central vowel /ɨ/ when the suffix is also high. Both vowels must be underlyingly high. This type of condition is known in the literature as Parasitic Harmony. I will discuss this further in the section on the OT analysis. The domain of harmony is the Prosodic Word as stray syllables are excluded from

this type of harmony. The direction of spreading appears to be right-to-left although I have no proof that left-to-right harmony could not exist if there were a [-ɨ] suffix.

3.2.4 Fronting

A different fronting process can be triggered on all central vowels by all front suffixes within the same foot. A comparison of the verbs *ɨskɨ* 'hear' and *isi* 'sit' helps to demonstrate this. Both verbs have [ɨ] as a root vowel and both verbs look similar in the perfective form. In both cases, an epenthetic [ɨ] is added:

(23) ɨsk-ŋ > (ɨs)(kɨ̄ŋ) 'understood' ɨs-ŋ > (ɨsɨ̄ŋ) 'sat down'

However, in the imperfective, the foot structure affects the spreading of [-back] from suffix to root. Spreading only occurs in the second example.

(24) a. ɨsk-ɛ > (i̱s)(kí:) 'understand' b. ɨs-ɛ > (i̱sí:) 'sit down'

Note that for the verb ɨski, there is another minimal pair that is relevant here. If the suffix is a high suffix, then the word undergoes the first type of fronting described in the previous section, as shown in (25a), but if the suffix is not a high vowel, and the word is made up of more than one foot, then neither type of fronting takes place, as shown in (25b). (25) shows that in cases where height harmony affects the suffix vowel and the surface vowels appear the same for the suffix, it may still be possible to detect the original suffix by what happens to other vowels in the word (and in this case, tone).

(25) a. ɨsk-i > (i̱s)(kī:) 'understand you (f.sg.)'
b. ɨsk-ɛ > (i̱s)(kí:) 'understand'

So the two types of fronting are: The fronting triggered by a non-high front vowel which observes foot structure (see 24b) and the fronting where both vowels must be high which ignores foot structure (see 25a).

The following examples show fronting spreading onto the [a] and [ɨ] root vowels, but only within the foot:

(26)

Beyond a foot, root a/ɨ (just height harmony)			Within a foot, root a/ɨ (height harmony and fronting of root vowel)		
a +-ɛ	>	a + ɛ	a +-ɛ	>	ɛ + ɛ
e.g. ba:d+ɛ	>	(ba:)(dɛ:)	e.g. bal + -ɛ	>	(belɛ:)[4]
ɨ +-ɛ	>	ɨ + i	ɨ +-e	>	i + i
e.g. vɨ:g + -ɛ	>	(vɨ:)(gi:)	e.g. bɨŋ + -ɛ	>	(biŋi:)

This process affects only central vowels, so:

(27) gɔl-ɛ > (golɛ:), *(gelɛ:)

Also, the parallel process for rounding does not take place.

(28) bal-u > (bɨlu:), *(bulu:)

The most important aspect of the fronting harmony as shown in (26) is that the foot is the domain. In the other types of harmony, the foot is involved because the Prosodic Word is made up of feet, but this is the only case where the spreading does not go beyond foot boundaries.

There is clearly some overlap between the two types of fronting and rounding harmony, so a comparison is made in (29).

(29)

	/-hi -hi/	/-hi +hi/	/+hi -hi/	/+hi +hi/
first syllable heavy	baad-ɛ > baadɛ No Change	baad-i > bɨɨdi No Change baad-u > bɨɨdu No Change	ɨsk-ɛ > (i̱s)(ki:) No Change	ɨsk-i > (i̱s)(ki:) Fronting cɨɨr-u > cuuru Rounding
first syllable light	bal- > (belɛ:) Fronting	bar-i > (biri:) Fronting	ɨs-ɛ > (i̱si:) Fronting	ɨs-i > (i̱si:) Fronting ɨs-u > (u̱su:) Rounding

[4] The presence of e rather than ɛ is explained by the fact that in non-head positions in a foot, the [+ATR] alternate is chosen. (See chapters 1 and 2.)

3.2.5 Motivation for right to left directionality

There are no examples of suffixes being the target of fronting or rounding. This could be because the process is directional, or it could be that suffixes are exempt. The second possibility seems likely as the vowel suffixes are made up of simply a vowel. If the information concerning fronting or rounding was lost, the morpheme would cease to be identifiable. Suffixes do undergo height harmony, but it seems that fronting and rounding involves too much change. (30) shows the vowel affixes which could be confused if harmony processes were allowed to target the suffixes.

(30) Vowel verb affixes

(aspect)	(medial / final)	(object)	
imperfective	ø /-ɛ	2 f sg	-y/-i[5]
imperative	ø	3 m sg	-u
		3 f sg	-a
		3 pl	-y/-i

The vowels involved in suffixes are:

(31) i u
ɛ
a

With **height neutralization**, the potential confusion is between -ɛ 'imperfective' and –i '2. sg f. object' 9 (and possibly 3 pl for certain tone patterns). Given the semantics, the context can often separate these two, and sometimes there are also other changes in the root, as in (32a), but not always, as in (32b). Tone also helps here.

[5] The 2 f sg and 3 pl suffixes each have two forms. In some words the two suffixes can differ, as in *iskiniy* 'I understand you', and *iskini:* 'I understand them'. But in many other words, the two forms differ only by tone. -y is more common than -i. More research is needed on the use of these two suffixes and the part that dialect plays in deciding which one is used. There is a tendency for low vowels such as [a] to take the –y form and for high and front vowels to take the –i form. But the pattern is not simple and is open to considerable variation.

(32)	a.	ɨsk-ɛ > (ɨ́s)(kí:)	'understand'
	vs.	ɨsk-i > (ī́s)(kī:)	'understand you (f)'
	b.	gun-ɛ > (gùnì:)	'wake'
	vs.	gun-i > (gùnì:)	'wake you (f)'

Confusion can generally only occur when someone is talking to a woman and there is a possibility that she could be the object of the verb in question. As this kind of neutralization does take place in Kera, it would seem that this potential for confusion is not seen as a big problem.

With the non-existent **fronting and rounding neutralisation**, there could potentially be slightly more confusion. The –a suffix '3 sg f object' could be confused with the imperfective -ɛ, as shown in (33a.). Tone does not help here. If all types of harmony were employed and –a was raised through height harmony as well as undergoing fronting or rounding, then there would be confusion with –u, or –i, both of which are also personal pronouns (see (33b.) and (33c.). According to Daniel Silverman (2006) this amount of confusion is not generally allowed to happen.

(33)	a.	fɛl-a > fela >*(felɛ:)	'see her'
	vs.	fɛl-ɛ > (fɛ́lɛ́:)	'see (imp.)'
	b.	gun-a > gunɨ > *(gunu:)	'wake her'
	vs.	gun-u > (gùnù:)	'wake him'
	c.	ɨs-a > ɨsɨ >*(ɨsi:)	'sit her down'
	vs.	ɨs-ɛ > (ɨ́sí:)	'sit (imp.)'

The potential confusion between the male and female third person suffix could cause major ambiguity. It may be for this reason that changes in suffixes are limited and that a preference for right-to-left spreading has developed as a result.

3.2.6 Total harmony

In monomorphemic words, all vowels are the same (or allophones of the same vowel) providing they are footed. In the examples in (34), all syllables are footed.

(34)	(kūŋ)(kūrūŋ)	'leather bag'	*(kuŋ)(kiriŋ)
	(ɗɨbɨ̌ɨ)(bɨ̌r)	'lizard'	*(ɗɨbɨɨ)(bir)
	(kɛ̄f)(tɛ̄r)	'book'	*(kɛf)(tir)
	(káa)(sáw)	'millet'	*(kaa)(siw)
	(kɔ̄ɔ)(mɔ̄m)	'rat'	*(kɔɔ)(mam)
	(fīlīi)(līw)	'hole in gourd'	*(filii)(lew)

However, monomorphemic words can end in a stray syllable which is not footed. Word-final light syllables are extrametrical and vowels in these syllables do not necessarily agree with the other vowels in the word. (35) gives examples of words with stray syllables that do not undergo total harmony. Note that some of these examples have the non-head allophones within the foot, but they are still in agreement with the head. The only vowels that do not agree are those that are unfooted.

(35)	(gǐɗii)rɨ̌ 'tribe, species'	*(gidɨɨ)rɨ
	(kɨ̄kɨ̄:)ɓā 'peace, cold'	*(kɨkɔɔ)ɓa
	(kúpúr)kī 'billy goat'	*(kupir)ki
	(cēcɛ̄r)kɨ̄ 'vertebrae'	*(cecɨr)kɨ
	(gə̀dàa)mɔ́ 'horse'	*(gədɔɔ)mɔ
	(dògɔ̀y)nà 'present time'	*(dogay)na
	(bāa)(sāy)mɔ̄ 'type of bird'	*(baa)(sɔy)mɔ

The roots of polymorphemic words also have total harmony. (Any epenthetic vowels may also agree, but this is dealt with elsewhere), for example:

(36)	gɨgɨɨr-n	> (gɨ̀gɨ̀ɨ)(rɨ̀n)	'my knees'	*gɨgɔɔrɨn
	kampar-m	> (kām)(pərām)	'your legs'	*kampirim

The domain for total root harmony is the Prosodic Word, including all of the feet in the root, but not any unparsed syllables.

This form of vowel harmony may not be productive. When a definite article -ŋ is added to the words in (35), the vowel does not change quality even though the final syllable is then a foot e.g. *(gədaa)mɔ > (gə̀dàa)(mɔ́ŋ)*. This should be compared with words which have an epenthetic vowel inserted before an -ŋ, for example: *baad-ŋ > bàadàŋ* 'washed'.

We discussed previously whether stray syllables are involved in total harmony, and we discovered in (18) that more than half of the words with stray syllables are compatible with a total harmony that covers the whole word. If height harmony is taking place, I would

expect a third to appear to have total harmony by chance alone. The actual amount seems a little higher than this. However, there are many examples where total harmony does not take place across strays so the domain is apparently the Prosodic Word, thereby excluding non-footed material. We can speculate that historically there may have been a length contrast on the final syllable which led to harmony on the long vowels and therefore made half of the final syllables harmonic. But synchronically there is no length contrast, so I presume that the Kera speaker must store all of the forms in the lexicon rather than subjecting them to a total harmony process.

I still need to account for the fact that suffixes do not undergo total harmony even though suffixes are footed and therefore part of the Prosodic Word.

(37)	fal – u > (fɨ̄lū:)	*fulu:	*fɨlɨ:	*fəla:
	tep-u > (tīpū:)	*tupu:	*tipi:	*tepɛ:
	gus-i > (gùsī:)	*gusu:	*gisi:	
	gɔl-i > (gùlī:)	*gulu:	*gili:	*golɔ:

In these examples, both the root vowel and the suffix vowel resist total harmony. So suffixes play no part in total harmony. This means that we cannot be certain about the direction of this spreading, although there is no reason why it shouldn't be right-to-left like all the other types of harmony (except height harmony which is bi-directional).

There remains one issue concerning stray syllables which will lead us to modify our view of total harmony slightly. We saw two cases in (9) where affixes were added to words with stray syllables and in the plural form, all vowels agreed: k-tɛŋka-w > (ké̱téŋ)(kɛ́w) and k-pɨrki-w > (ki̱pɨ́r)(kɨ́w). Yet we had already established that when the definite article -ŋ is added to words with strays, the stray vowel does not change qualities. So we have two different patterns emerging here.

(38)	sg.	pl./def.art.			
	(tɛŋ)ka	k-tɛŋka-w	>	(kétɛ́ŋ)(kɛ́w)	'mill stone pl.'
vs	(tɛŋ)ka	tɛŋka-ŋ	>	(tɛ̄ŋ)(káŋ)	'the mill stone.'
	(pɨr)ki	k-pɨrki-w	>	(kɨ́pɨ́r)(kɨ́w)	'mountains'
vs	(pɨr)ki	pɨrki-ŋ	>	(pɨ́r)(kḭ̂ŋ)	'the mountain'

The spreading in the plural form isn't always a left-to-right spreading of the root vowel, as an alternative form for 'mountains' shows:

(pɨr)ki	k-pɨrki-aw	>	(kə̰pár)(káw)	'mountains'

Here, the plural includes an [a] vowel which spreads throughout the word. Most nouns do not have a plural form, so I do not have enough examples of plurals to form a rule as to when the [a] vowel plays a part, but it is interesting to note that when it does spread through the word, it produces total harmony affecting all vowels including those in the root. This is unlike object suffixes which only produce total agreement in epenthetic vowels. It is probably safest to assume that the spreading in plurals (and words marked for gender) is left to right when a root vowel is involved and right to left when a suffix vowel spreads.

These examples suggest that there are two levels of affix, one of which is more linked to the root and which could be considered part of the stem, and the other which is more loosely connected to the word. Harris (1987, 1990) discusses similar analyses in Southeastern Bantu and English respectively where certain suffixes undergo phonological changes with the root and which can be considered to be part of the stem (and are considered to be derivational), while other prefixes remain impervious to the contiguous segments (and are considered to be inflectional). Examples of root level derivational suffixes in English would be *–ity, -ic, -ant*, and also irregular forms such as *blew, mice, sang*. Whereas word level inflectional suffixes would be *–ed, -ness, -ly* and compounds such as *blackbird.* At root level, where lexical phonological processes take place, the addition of a suffix is likely to have certain effects on the rest of the word, such as *vain/vanity*, but at word level, or above, the post-lexical processes leave the internal structure of the word intact (See also Bermúdez-Otero and McMahon 2006).

In a similar manner, I could say that there are two or even three levels in Kera. The definite article –ŋ is best considered as a phrase level suffix or clitic, and therefore not part of the stem. It is clear that this clitic forms the coda of head syllables within the foot, but the parsing takes place at phrase level, not at word level, so the vowel harmony which works at root or word level does not provoke further changes if a clitic is added. Note the

position of the –ŋ definite marker in the following example with a noun phrase. The definite article is not attached to the noun, but rather to the noun phrase:

(39) pɨrki bɔblɔ-ŋ > (pír)(kîbɔ̀b)(lɔ̀ŋ) 'the big mountain'
mountain big-def.art

On the other hand, the plural affix (and presumably masculine and feminine which are of a similar nature) is working at stem level. This means that the domain for total harmony is now the Prosodic Word within the stem.

(40) k-pɨrki-aw kɨmtɨŋ > (kə́pár)(káw) (kɨ̂m)(tɨ́ŋ) '(the) big mountains'
mountain-PL. big

There is no evidence for whether we should categorise the object/possessive suffixes such as –m '1 sg' and -ŋ '2 pl' as inside or outside the stem. When epenthetic vowels are introduced before such a suffix, it has the quality of a copy vowel which might suggest that it is closely linked to the stem. But when these suffixes consist of a vowel, they do not harmonize with the stem and epenthetic vowels agree with the suffix vowel rather than the root vowel. This suggests a certain distance morphologically between the object suffixes and the stem. So I could conclude that object pronoun suffixes operate at word level (as opposed to stem level) and are equivalent to the inflectional suffixes described by Harris. However, this will not affect our analysis in any way. If this is correct, then the plural affix described above would be considered to be in the derivational category (or stem level). This would be in keeping with the behaviour of such affixes in other languages. There is a tendency for these affixes to undergo vowel harmony to a greater extent, for example in Bantu languages undergoing ATR harmony, the harmony domains often work at stem level. There is also a tendency for irregular forms to appear at this level as the forms become lexicalized. (John Harris p.c.). The examples given here imply that there may be a derivational/inflectional system in Kera, but there is insufficient data to come to firm conclusions.

3.3 Vowel harmony and domains

In this section, we will look further at the domains of vowel harmony and the prosodic structures involved in defining these domains. We will then examine in more detail the issues surrounding the stray syllables which are not parsed and therefore outside of the harmony system.

To remind the reader, I have already argued that the Kera foot is iambic, CV: and CVC syllables count as heavy. Stray light syllables are not parsed in the word level phonology, although at phrase level they may be footed with a following heavy syllable.

3.3.1 Vowel harmony domains

We saw in (7) that the domains for harmony are as follows:

(41)

Harmony	Domain
Epenthetic feature-filling	PrWd
Height	MWd
Fronting and rounding	PrWd
Fronting	Foot
Total	PrWd in stem

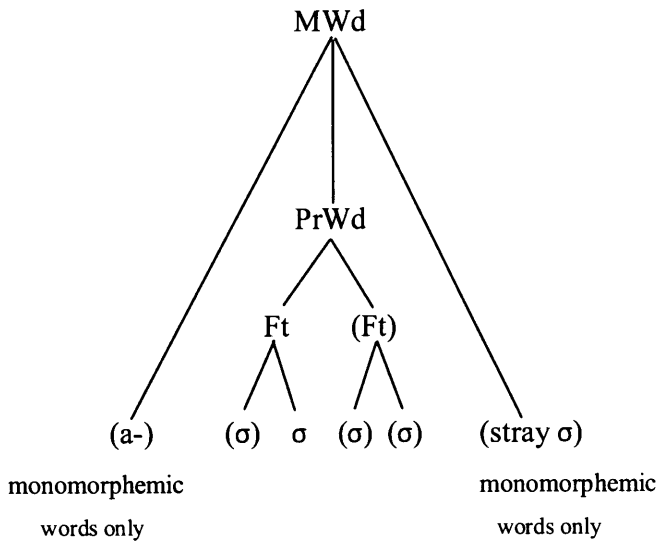
In fronting harmony, the foot is a domain in its own right. This is typologically unusual; other languages that probably use the foot as a domain include Ascrea Italian and Andalusian Spanish, and related dialects (Hualde 1989, Rose and Walker 2004, Archangeli and Pulleyblank 2007, Jiménez and Lloret 2007), but these appear to be the only languages cited in the literature. In Ascrea, only stressed mid vowels undergo height harmony and the trigger is a high vowel to the right of the target.

(42)	(sórda)	'deaf (f sg)'	(súrdu)	'deaf (m sg)'
	pre(fónna)	'profound (f sg)'	pre(fúnnu)	'profound (m sg)'

This example implies that the domain of harmony is a trochaic foot.

Returning to Kera, the Morphological Word is made up of feet and stray segments. The Prosodic Word, on the other hand, is defined as being the collocation of all the feet in the word, but not including stray syllables or the prefix a- when it is outside of the parsing (see §3.3.3). The structure of Kera words can be summarized as follows:

(43) *Morpho-phonological structure*



a.	**a-**	**du**	**gur**		**ni**	adugurni	'toad'
						a[(dùgùr)]nì	
b.			**gɔl**	**dɛ:**		gɔld-ɛ	'to search'
						[(gɔ̀l)(dɛ́:)]	
c.			**wɨ**	**tu**	**nu:**	waat-n-u	'spoke to him'
						[(wɨ̄)(tūnū:)]	
d.		**gə**	**dar**	**gə**	**ɗaw**	g-dɔrgɔɗ-aw	'granaries'
						[(gə̀dàr)(kə́ɗáw)]	

(43a) shows a case where the a- prefix and stray syllables are outside of the domain of the Prosodic Word. Total harmony only applies to syllables that are part of the Prosodic Word and contained in the stem. (43b) shows that suffixes are not treated in the same way as stray syllables. The suffix is footed (and lengthened) and therefore is contained in the Prosodic Word. (43c) is again within the Prosodic Word and we can see that the suffix vowel spreads left onto the epenthetic vowel. (43d) demonstrates that the plural affix (which is split into prefix and suffix) is also in the Prosodic Word and therefore subject to total harmony. The

-w suffix is part of the stem, so total harmony occurs with the /a/ vowel replacing the root vowels.[6]

3.3.2 Final stray syllables

Stray syllables are made up of light syllables which cannot be feet on their own. In words where the penultimate syllable is heavy, a stray syllable will be unparsable as an iambic foot.

We have seen that stray syllables do not generally undergo fronting, rounding or total harmony. As stray syllables are not footed, they provide the evidence that the foot structure plays an important part in defining the domains of harmony: Disharmonic vowels are limited to unfooted syllables. (44) Shows us that disharmony does not exist within or between feet in roots.

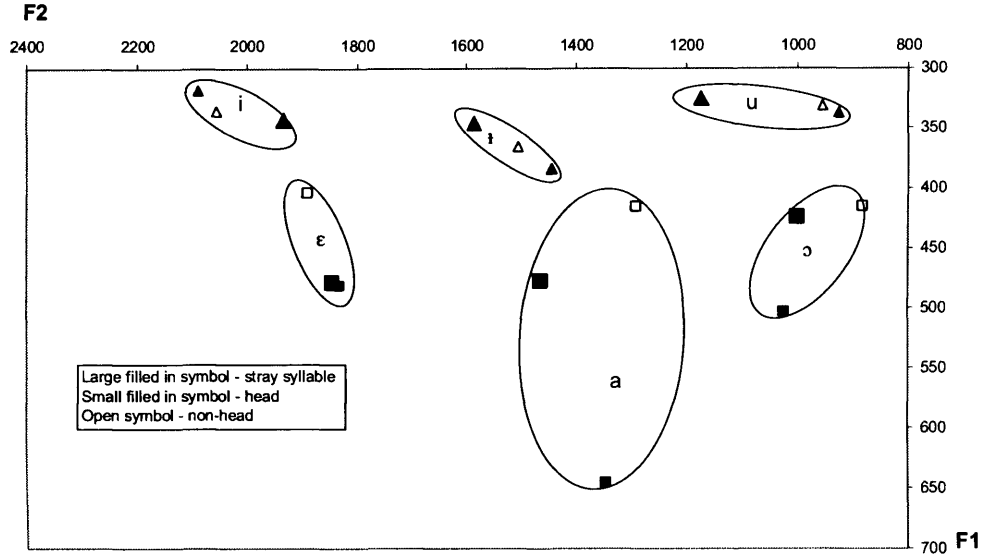
(44)

	footed	strays
harmonic	(kətar)(taw) (kuŋ)(kuruŋ)	(baa)ŋa (kin)ti
disharmonic	*(kətar)(tiw) *(ketɔ:)	(kəsaa)(nan)ti (gədaa)mɔ

I have already established in chapter 2, §2.2.2, that the duration of stray vowels is shorter than a head vowel but longer than a non-head vowel. This suggests that they are different from footed syllables. Further support for this comes from the quality of stray vowels. They appear to be more like heads than non-heads, but a close inspection reveals that the quality is also not the same as either head or non-head. In (45) which plots the vowels of 12 speakers (mostly from the Town and the Town/Village dialects), we can see that the F1 value of the stray vowels (larger symbols) appears to be limited in that it cannot be greater than around 500 Hz. Each point represents the mean of at least twenty measurements.

[6] Note in (43d.) that the singular form would be *dɔ̀rgɔ̀d-i* with an –i obstruent release vowel (see chapter 2, §2.4). This release vowel is not part of the phonological structure and it plays no part in the plural form.

(45) *Plot of vowels for 12 speakers including stray vowels*

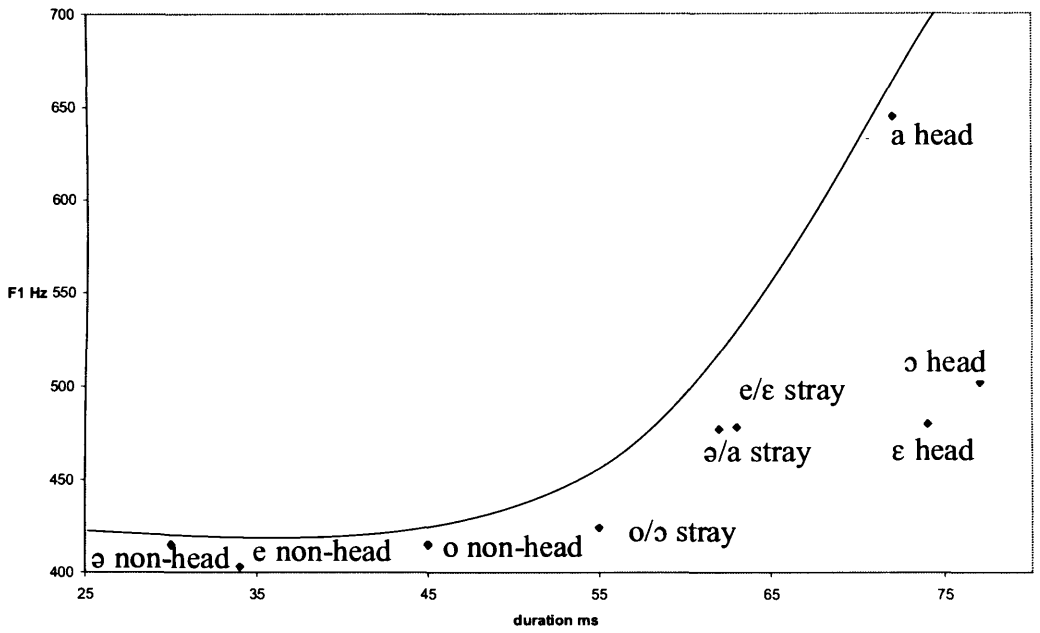


It appears that there is no limitation on high vowels. We could hypothesize that stray vowels cannot be low because they do not have enough duration to reach the lower vowels (using a similar argument to that used for the gradient approach with regard to the ATR allophones, discussed in chapter 2). The default vowel sound which is produced as a transition between consonants tends to be a schwa sound (An example of this is shown in (99) below). This implies that a low /a/ sound would be the furthest from this default and a stray syllable containing /a/ would not have the duration required to move from the default all the way to the low vowel. Barnes (2006) gives many examples of languages which have reduced vowels in a similar way because there is not enough time in short vowels for the movement to a low vowel (See discussion in chapter 2, §2.2.3.1).

Although stray syllables are generally not lengthened, they can be lengthened at the end of utterances. There is good precedent for a phonetic lengthening effect at the end of domains. Newman and Van Heuven (1981) and Steriade (1994) note that this occurs in Hausa in pre-pausal position where the short/long distinction becomes less obvious in terms of duration but is still marked with a final glottal stop for underlyingly short vowels. The distinctions in vowel quality for the features [back] and [round] are preserved more faithfully in phrase-final position. Barnes (2006) concludes that Hausa has stress-based vowel reduction, but it would be interesting to examine this question further in the light of the Kera findings. Kera, like Hausa, has phonetic lengthening in utterance final position. Vowels in stray syllables at the ends of phonological phrases also have a longer duration than non-head vowels, but not because of phonetic lengthening; instead, the duration of the non-heads is phonetically reduced to emphasize the iambic relationship between head and non-head. The stray syllable at the end of the phrase is neither lengthened nor shortened.

As we saw in chapter 2, the same durational argument can be used for non-head allophones, they are higher than head vowels because the vowel is too short for a lower position to be reached. We can test this by plotting the mean duration against the F1 value for each of the vowels. This is shown in (46). A curve has been added to represent the space beyond which the vowel cannot go. As the F1 value is an inverse indication of vowel height, this hypothesis claims that large F1 values can only be achieved in vowels of long duration, i.e. head vowels. (46) does not include high vowels as they have low F1 values in every situation and would therefore be at the bottom of the graph.

(46) *Plot of F1 against duration for each type of vowels*



Most vowels are close to the line, but the head vowels for /ɔ/ and /ɛ/ are not as low as they could be (i.e. the F1 value is smaller than expected). That does not disprove the hypothesis as presumably the target F1 value for these vowels is around 500 Hz and there is no reason for these vowels to be lowered further. I cannot prove this hypothesis, and certainly an in-depth study would have to consider the equation of the curve of the line in (46) and whether this reflects the speed of movement of the articulators. This is beyond the scope of this thesis, but the explanation is at least plausible. If true, then we have different phonetic tendencies with the following properties for non-high vowels:

(47) *Vowel categories for non-high vowels*

Vowel	Duration	Height/F1	Parsed	Harmonizes
Head	Lengthened	Any F1 value	Yes	Yes
Non-head	Shortened	Only small F1 values	Yes	Yes
Stray	Middle	Small or medium F1	No	No

There is one other area where we could look for evidence that stray syllables are different from the other types and that is whether they can carry tones. All of these syllables can carry tone, but there is a hierarchy. If a word has two tones and two feet, one tone will emerge on each foot. If the word has one foot and a stray syllable, the stray syllable will take the second tone rather than the non-head. The only time that non-heads carry tone is if the word has two tones and only one disyllabic foot.

(48) *Placement of two tones on word*

a)	2 feet:	(L)(H)	(dàk)(tə́láw)	'bird'
b)	1 foot + stray syllable:	(L)H	(gə̀dàa)mɔ́	'horse'
c)	1 foot:	(LH)	(hùɗúm)	'hole'

Unfortunately for our argument, a) and b) could be argued to be the same pattern. If the stray syllable in b) was a foot, the tone pattern would not change. But although the tone facts are less conclusive, overall it is clear that stray syllables are being treated differently from footed syllables and that we need to have a separate category in our description of Kera.

Some linguists would prefer to analyze such final stray syllables as degenerate feet. In support of this view, Kager (1995a) states the principle of exhaustivity: all syllables of a word must be organized into feet. For Kera, if these stray final syllables were thought of as the heads of degenerate feet, we could argue that the allophones of the non-high vowels appearing in these syllables also appear in the heads of feet, except for the vowel /a/ as discussed above. Nevertheless, I have chosen to treat these syllables as unfooted because of the vowel harmony facts which suggest that the vowels in unparsed syllables are not subject to the same harmony processes. The duration and quality of stray syllables also suggest that we have something other than head syllables here (see §2.2.2 discussion on strays). In addition, these syllables do not undergo the same deletion or lengthening processes as CV syllables preceded by a CV syllable. Hayes (1995), Prince (1980), Kager (1989) and McCarthy and Prince (1990b, 1995b) tend towards treating stray syllables as unparsed. Stray syllables are limited to noun and adjective roots. This fits with the pattern of extrametricality in Spanish and Italian. Den Os and Kager (1986) observe that

extrametricality only occurs in stems in these languages. So overall, the evidence points to stray syllables being in a separate category.

3.3.3 Other non-parsed elements

There are a few final details that we need to consider: A number of nouns have the animate or locative prefix a-. These words have now become like frozen forms and the words act like monomorphemic words except that the a- prefix is not affected by any vowel harmony.[7] a- is generally not parsed.

(49) *Nouns with a- prefix*

a(dùgùr)nì	'toad'	a(lāk)(wār)	'type of fish'
a(tɔ́l)(tɔ̄m)	'bass flute'	a(tìgǐr)(ǐŋ)	'one string guitar'

As well as stray syllables and frozen prefixes and suffixes such as a-, there is another phenomenon which should also be mentioned here. In chapter 2, §2.4, I referred to the obstruent release [–i]. I established that this release is not part of the phonological structure except when it has undergone a process of phonologization. This [-i] does not conform to the vowel harmony rules that operate in the rest of the word. Note that even though the stray syllables described above can be subject to height harmony, this [-i] does not trigger or undergo height harmony or any other kind of harmony. At most times this [–i] is disregarded in the parsing of feet. However, when the definite article -ŋ is added to some of these words, the –i becomes part of the foot structure. From this I deduce that the [-i] is becoming phonologised, although the quality of the vowel does not change. This could be because the processes of vowel harmony are no longer very productive or because the definite article –ŋ is acting at phrase level and harmony takes place at word level. In any case this [-i] never attracts, blocks or triggers harmony. Note that in all of these words, the consonant preceding the [-i] is an obstruent. There are no words with [-i] following a sonorant.[8] So for example **(kan)i* does not exist.

[7] There are few nouns beginning with vowels other than a-, so it is unclear whether only the a- prefix is excluded from total harmony or whether this is a general restriction on all vowel initial words. All vowel initial words apart from those with the a- prefix are pronounced with a preceding glottal stop. This glottal stop may block total harmony spread. However, there is not enough data to verify this.

[8] Apart from *kuli* 'house' which seems to be an exception.

(50) *Words with default -i added to word final obstruent (all attested structures)*

(kās)i	'hands'	a(dɛ̀g)i	'plant'
(dɔ̀r)(gɔ̀ɗ)i	'granary'	a(lɛ̄m)(ɗɛ̄g)i	'whip'
(pɔ́ɗák)i	'light'	a(gɔ̀lɔ̀s)i	'fish'
(dɛ̀ɓ)(lɛ̀k)i	'blemish'	a(cɛ̄ɓ)(lɛ̄k)i	'bulb'
(bɛ̀zɛ̀r)(nɛ̀k)i	'fox'		

To summarise:

(51) *Types of final syllable in monomorphemic forms*

UR of final syllable(s)	Surface form		Vowel Harmony	Examples
CV Stray	CV/CV:	The only place where it remains unlengthened and unfooted is in phrase final position.	No obligation to agree (even when lengthened)	/kunti/ (kūn)tí 'flour'
CV suffix		Vowel suffixes might be underlyingly short, but they are always footed in the surface realization.	Height harmony, not total harmony	/tuuk-ɛ/ (túu)(kî:) 'arrive'
CVC	CVCi default -i	-i is an obstruent release, a phonetic addition not included in the parsing, it surfaces only in slow speech or phrase final.	No agreement	/dɔrgɔɗ/ (dɔ̀r)(gɔ̀ɗ)i 'granary'
	CVC	For final consonants that are not obstruents.	Agrees with previous syllable	/kaasaw/ (kāa)(sāw) 'millet'
CVCV	(CVCV:)	Disyllabic foot, second vowel lengthened	Vowel agreement	/tara/ (tɔ́rá:) 'a run'
CVV		No proof that these exist.		

We can now examine the combinations of vowels that are admissible within feet, between feet and beyond feet in a list of the combinations for monomorphemic words including nouns with the a- prefix.

(52) *Possible vowel combinations*

( )		( )( )		a-( )( )-X	
Within feet		Between feet		Between foot and non-foot	
i i	(mīdī:) 'miracle'	i i	(sīs)(wīdī:) 'early morning'	a- i i X	a(tīfīn)kū 'aubergine'
ɨ ɨ	(kɨ̂kɨ̂w) 'flies'	ɨ ɨ	(gɨ̀bɨ̀r)(lɨ̀ŋ) 'wasp'	a- ɨ ɨ X	a(mɨ̄ŋɨ̄)lī 'chameleon'
u u	(túkúr) 'plate'	u u	(kūŋ)(kūrūŋ) 'leather bag'	a- u u X	(kúpúr)kí 'bull'
e ɛ	(bègé:) 'cattle'	e ɛ e ɛ	(kēsɛ̄r)(dɛ̄ŋ) 'traditional skirt'	a- e ɛ X	a(dèŋɛ̀s)i 'trap'
ə a	(kə́rə́m) 'women'	ə a ə a	(gə̀də̀r)(gə́dǎw) 'granaries'	a- ə a X	a(cə̄kə̄d)i 'fork in tree'
o ɔ	(sòlɔ́y) 'money'	o ɔ o ɔ	(gòdɔ̀r)(mɔ̀y) 'leach'	a- o ɔ X	a(gòlɔ̀n)a 'type of tree'

3.4 OT analysis of vowel harmony

For this discussion, I assume that both forms of [+/- ATR] allophones are essentially the same vowel, satisfying AGREE and ALIGN constraints, so for example [e] and [ɛ] in the same word are taken to be agreeing for features. For most forms of harmony, I will be following the example of Cole and Kissebirth (1998), and Ringen and Vago (1998) in using ALIGN constraints, particularly of the form:

(53) ALIGN F L PRWD: Every parsed [F] specification must be aligned with the left edge of a Prosodic Word.

This gives us directional harmony from right-to-left. I will also be using other standard constraints within a correspondence account of vowel harmony as used by the same authors, and Beckman (1997), such as:

(54) SPECIFY (F): Vowels must be specified for the feature F,
DEP F: Every segment with feature F in the output has a corresponding segment with feature F in the input.
MAX F: Every segment with feature F in the input has a corresponding segment with feature F in the output.

3.4.1 Epenthesis

I need to account for two situations:

(55) a) Epenthetic vowels with a consonant suffix: root vowel spreads L to R
b) Epenthetic vowels with a vowel suffix: suffix vowel spreads R to L

I have established the fact that spreading occurs from right-to-left where possible and that the domain of spreading is the Prosodic Word.

I will start by considering the case where the only underlying vowel is the root vowel. The epenthetic vowel will have the same features if I make sure the vowel is specified and that no other vowels are introduced. I will be making use of DEP F and SPECIFY as defined in (54).

(56) gɔ̀ld-n 'searched for me'

gɔld-n	DEP F	SPECIFY
☞(gɔl)(dɔn)		
(gɔl)(dən)		*
(gɔl)(din)	*!	

The next situation that we have to deal with is where there is a suffix. I need to make sure that spreading occurs from right-to-left as far as the root, but no further. This is covered by the constraint ALIGN F L PRWD as defined in (53).

Although there is no total harmony between root and suffix, there is agreement between the suffix and any epenthetic vowels. The introduction of epenthetic vowels could lead to two possibilities. Either the root vowel could spread or the suffix vowel could spread. We have already seen that if there is no suffix vowel, the epenthetic vowel agrees with the root. However, if there is a suffix vowel, the epenthetic vowels agree with that vowel.

(57) Examples of epenthetic vowels

wa:t-n-i>	(wɨ:)(ɨnɨ:)	'spoke to you (f)'[9]
mirk-t-u>	(mɨr)(kūtū:)	'greet him repeatedly'
wa:t-n>	(wā:)(tān)	'speak to me'
mirk-n>	(mɨr)(kɨn)	'greet me'
mirk-t-n-u>	(mɨr)(kūt)(nū:)	'greeted him repeatedly'

In the vowel suffix cases, we have suffixes made up of just one vowel. If the suffix were to harmonise completely with the root in the same way as the epenthetic vowel agrees with the root, then all of the information from the suffix would be lost. The suffix morpheme must therefore be protected from harmonizing to this point. It must have some surface phonological effect, keeping some features. To cover these cases, I will need the constraints:

(58) REALISE MORPH: Realize the morpheme in an overt and detectable manner. (Akinlabi 1996, Gnanadesikan 1997, Kurisu 2001, based on Samek-Lodovici 1993).

MAX RT F: Every segment with feature F in the input has a corresponding segment with feature F in the output. The domain where this applies is the root.

MAX RT F is a positional faithfulness constraint (Beckman 1997, Lombardi 1999). We might be tempted to replace MAX RT F by MAX F, and this would not be a problem at this stage, but later on we will see that MAX F must be ranked below ALIGN F L PRWD.

(59) mirk-t-n-u

mirk-t-n-u	REALISE MORPH	MAX RT F	ALIGN F L PRWD
☞(mir)(kut)(nuu)			*
(mir)(kit)(nuu)			**!
(mur)(kut)(nuu)		*!	
(mir)(kit)(nii)	*!		

In summary, for epenthetic vowels, the grammar is:

(60) DEP F, SPECIFY, REALISE MORPH, MAX RT F >> ALIGN F L PRWD

[9] It would be helpful to be able to contrast this with an example such as: hat-n-u > *(hɨtɨ)nu, but unfortunately there are no examples of this kind because hat-n-u does not contain a disallowed consonant cluster to force the addition of an epenthetic vowel. So hat-n-u > (hɨt)nu 'taught him'.

3.4.2 Height harmony with height dominance

Height harmony operates within the Morphological Word. If any vowel is high, all vowels are high. In other words, height harmony involves the spread of [+high]. This feature is dominant, regardless of whether it is found on the root vowel or the suffix. In this section we need to cover the following cases:

(61)

a) All vowels low – No height harmony

b) Height harmony spreads right

c) Height harmony spreads left

d) Stray syllables are outside of the system

e) Suffixes are part of the system

We need the following constraints (following the general pattern for MAX constraints outlined in (54):

(62) MAX [+high]: Every segment with the feature [+high] in the input has a corresponding segment with feature [+high] in the output

MAX [-high]: Every segment with the feature [-high] in the input has a corresponding segment with feature [-high] in the output

The high vowels keep their [+high] feature while the [-high] vowels change, so the ranking for these two constraints is:

(63) MAX [+high] » MAX [-high], (following Beckman 2003)

We also need constraints for spreading. For most types of harmony, the direction of spreading is right-to-left and therefore ALIGN constraints are appropriate. In this case though, the height feature is dominant and the spreading can therefore occur in both directions. For this reason the most appropriate constraint is an AGREE constraint (following Padgett 2002, Kiparsky and Pajusalu 2003, and Beckman 2003, also named SPREAD, but essentially the same constraint). I could of course use ALIGN left and ALIGN right as conjoined constraints. The AGREE constraint can be seen as a cover constraint for these. The domain of spreading is the Morphological Word rather than the Prosodic Word because stray syllables are also included in height harmony.

(64) AGREE MWD [high]: All vowels agree for the feature [high] throughout the Morphological Word.

The ranking I will use is as follows:

(65) MAX [+high], AGREE MWD [high] » MAX [-high]

In the following tableau, height harmony spreads to the left.

(66) sɛɛn-i > siini 'your (f) brother'

-hi +hi /sɛɛn + i/	MAX [+hi]	AGREE MWD[hi]	MAX [-hi]
+hi ☞ (sii)]ni			*
-hi +hi (sɛɛ)]ni		*!	
-hi (sɛɛ)]nɛ	*!		

In the next tableau, height harmony spreads to the right.

(67) guud-a >guudɨ 'her stomach/ in her'

+hi -hi /guud+a/	MAX [+hi]	AGREE MWD[hi]	MAX [-hi]
+hi ☞ (guu)(dɨɨ)			*
+hi -hi (guu)(daa)		*!	
-hi (gɔɔ)(daa)	*!		

Note here that the suffix changes features. This implies that the ranking for REALISE MORPH (see (58)) is lower than the first two constraints above. If not, the suffix would not be allowed to undergo height harmony.

The examples above show that this grammar will spread [+high] if it is found anywhere within the Prosodic Word. Stray syllables are also included. In (68) I follow the richness of the base principle and therefore assume a disharmonic input.

(68) (pʉ)(rɨŋ)ki 'old man'

+hi -hi /pʉrɨŋkɛ/	MAX [+hi]	AGREE MWD[hi]	MAX [-hi]
+hi ☞ (pʉ)(rɨŋ)ki			*
+hi -hi (pʉ)(rɨŋ)kɛ		*!	
-hi (pɛɛ)(rɛŋ)kɛ	*!		

3.4.3 Front and rounding harmony of underlying high vowels

Unlike in Kera height harmony, the fronting and rounding harmony always spreads from the suffix to the root, i.e. from right-to-left. The domain is the Prosodic Word, the trigger is a high suffix and the target is a high central vowel in the root. So before [+high] suffixes, /ɨ/ harmonizes its backness and rounding. We might consider using ALIGN F L PRWD but (59) shows us that this constraint must be relatively low ranked, and it does not distinguish between a target of [ɨ] or [a]. We cannot suppose that /a/ is immune from this harmony as a [+low] vowel, because /a/ can be fronted in certain circumstances as we discuss in the next section. Another approach is therefore to say that [ɨ] undergoes harmony whenever possible. This is in keeping with the behaviour of high central vowels in several languages including Turkish where [ɨ] only occurs if there are no harmonic triggers available. (Archangeli and Pulleyblank 2007). In systems with front and back vowels, Flemming (1995, 2004) notes that the high central vowel is marked so that the following hierarchy exists: *ɨ » *i, *u. Kera is unusual in that [ɨ] can be in head position in the foot and can be lengthened, but even with this, it generally only survives in the absence of other vowels. So for a first draft of a grammar, I can make use of these facts, and use IDENT F to block the other vowels from undergoing spreading.

(69) *First draft of a fronting and rounding grammar (to be revised)*

*ɨ » IDENT F » *i, *u, *o, *e, *a

This grammar will cover the case where both trigger and target are high, allowing fronting to take place, and it will exclude the case where both trigger and target are not high. But we still have a problem. The chart in (33) is repeated here to demonstrate what the problem is.

(70) *Conditions for fronting and rounding harmony*

	a. /-hi -hi/	b. /-hi +hi/	c. /+hi -hi/	d. /+hi +hi/
first syllable		baad-i > bɨidi		ɨsk-i > (i̱s)(ki:)
heavy	baad-ɛ > baadɛ	No Change	ɨsk-ɛ > (i̱s)(ki:)	Fronting
	No Change	baad-u > bɨidu	No Change	cɨir-u > cuuru
		No Change		Rounding

This grammar can deal with case a. and case d. but we are still left with two cases to account for. If either the trigger or target is underlyingly high, and the other is underlyingly low, height harmony will cause all vowels to be high in the surface form. In both of these cases, fronting and rounding does not take place. Our grammar at present will incorrectly select the candidate where it does take place.

In (71) we see how the wrong candidate is selected. In this and subsequent tableaux, height harmony is assumed as the height harmony constraints are higher ranked. The features [back] and [round] are not shown here as they are not affected by the constraints.

(71) *Selection of wrong candidate with this grammar*

-hi +hi | | /baad+i/	*ɪ	IDENT F
(bɨi)(dii)	*!	*
☞☹ (bii)(dii)		*

Cases (70b) and (70c) would not be a particular problem for a derivational account as rule ordering could make sure that fronting and rounding takes place before height harmony. But in OT, a change in the order of constraints would not solve the problem.

We could use an approach such as that suggested for Parasitic Harmony in Yawelmani Yokuts (Cole and Kissebirth 1998). This involves a fresh approach to OT and the limitations on what constraints can do. The standard approach in OT also involves conjoined constraints. However, in Kera, this is not necessary because we can find a solution to case b. in terms of underspecification and case c. is extremely rare. At present I am aware of only two words which have the right conditions for case c. (namely a verb with a /ɨ/ root vowel) and one of these, *vɨigi* 'to empty (stomach)' i.e. 'to forgive', has

become a frozen form which does not take suffixes other than the imperfective -ɛ. (The other case is the verb *ɨsk-ɛ > ɨski* 'to understand', where fronting does not take place because the suffix is not underlyingly high.) For this reason, I propose that we consider case c. to have too few examples for a reasonable analysis, and we will concentrate on case b. If more examples were to come to light in case c., a similar approach to that of Cole and Kisseberth (1998) for Parasitic Harmony would be needed.

Case (70b) is not rare, so we cannot discount it as an exception. The kind of words that fall into this category are nouns and verbs with a root vowel /a/ and a suffix –i. These undergo height harmony and our grammar above would predict that fronting would also take place, as we saw in (71), but it doesn't. If we could have the constraint */ɨ/, our problem would be solved, but constraints deal with surface forms, not underlying forms. We have already noted that /ɨ/ generally only survives if there are no other vowels in the word (although case b. verbs are an exception to this). It is also true that in a number of other Chadic languages /ɨ/ is considered to be a 'non-vowel'. Hyman (2001b) refers to some Bantu languages that have similar patterns. For example, the vowel /I/ in Gunu is realized as [i] in the presence of ATR, but otherwise as [ɛ]. This vowel is transparent to rounding harmony, and he refers to the vowel as 'unspecified'. So maybe the /ɨ/ vowel in Kera is totally underspecified and readily takes on the features of other vowels in the word. The use of underspecification is developed in Archangeli and Pulleyblank (1989, 1994) and Pulleyblank (1986, 1988, 1998) for the Yoruba vowel [i] based on its behaviour in vowel harmony. Abaglo and Archangeli (1989) compare Yoruba with Gengbe. Both languages have the same oral vowel inventories, but they claim that in Yoruba, [i] is underspecified and [e] is [-high], while in Gengbe [e] is underspecified and [i] is [+high]. Another language which could employ underspecification is Ineseño (Applegate 1971). Like Kera, this language has 6 underlying root vowels. [ɨ] has a limited surface distribution as it is only found in the combinations: [u - ɨ], [i - ɨ] and [a - ɨ], whereas the combinations for other vowels appears unrestricted.

Returning to Kera, a certain amount of underspecification looks promising, but total underspecification for the /i/ vowel is impossible because /ɨ/ triggers height harmony. e.g. cɨɨr + a > cɨɨrɨ 'her head'. Therefore I propose that /ɨ/ is specified for [+high], but underspecified for [back] and [round]. This means that our grammar could be:

(72) SPECIFY > MAX F

Underspecification in OT is readily accepted for epenthetic vowels, as shown in the work of Lombardi (2003), and it is considered the best approach by Hong (2002) when analyzing vowel harmony in Classical Manchu. The front high vowel [i] is analyzed as underspecified

for [ATR]. If this is allowed, the transparency of [i] to [ATR] harmony can be accounted for. Hong comments that allowing underspecification is in keeping with the concept of the richness of the base. Itô, Mester and Padgett 1995 also make some use of underspecification in OT. They note that underspecification is already used in OT for sonorants which are usually unspecified for [voice] and they apply this fact to Japanese Rendaku. With this precedent, we will see if underspecification can be used in our account of Kera fronting and rounding harmony. We will consider the case for fronting, but rounding would be dealt with in the same way.

We need to verify if the grammar in (72) gives us the desired result for each of the cases discussed. We look first at case a. and case d.

(73) ~~ciir~~ + i > ci□iri□: 'your head' *(Case a.)*

	SPECIFY	MAX F
+hi +hi /~~ciir~~ + i/ -ba -rd		
+hi ☞ (cii)(rii) -ba -rd		*
+hi (c~~ii~~)(rii) -ba -rd	*!	
+hi (c~~ii~~)(r~~ii~~)	**!	*

Vowels which are already specified for back and round such as /u/ and /a/ do not violate SPECIFY and therefore will not undergo any changes from this ranking.

Case (70d) is trivial because all vowels are fully specified and therefore there is no motivation to change. But it is shown here for completeness. I am assuming that the constraint *(-bk, +rd) is undominated so that we never have front rounded vowels (see (82)).

(74) baad-ɛ > bàadɛ́: *bɛɛdɛ: 'to wash'. Case d. *(-hi features are assumed)*

+ba -ba | | /baad-ɛ/	SPECIFY	MAX F
+ba -ba | | ☞ (baa)(dɛɛ) | | -hi -hi -rd -rd		
-ba (bɛɛ)(dɛɛ) | | -hi -hi -rd -rd		*!

Case c. is rare, so I will not deal with it here. Case b. is an important case for us. Again, height harmony is assumed, so [baadi:] is not considered.

(75) baad-i > bɨ̀ɨdɨ́: *biidi: 'wash you (f)'. *Case b.*

-hi +hi | | /baad-i/ | | +ba -ba -rd -rd	SPECIFY	MAX F
+hi ☞ (bɨɨ)(dii) | | +ba -ba -rd -rd		*
+hi (bii)(dii) -ba -rd		***!

MAX F is a gradient constraint and the asterisks are awarded on the basis of one per feature. Note here that [ɨ] is fully specified in the winning candidate, so it is only the underlying /ɨ/ that is underspecified.

We need to verify that the grammar covers us for the case when /ɨ/ is allowed to surface as [ɨ]. Let us consider cɨɨr-a > cɨɨrɨ:. This is not fronting harmony, but it is an

example where the [ɨ] surfaces. Again height harmony rules out any candidates containing [a]. The second and third candidates are ruled out because of underspecification. Of course, between the three candidates here, we cannot tell which analysis is correct from the surface form, so this tableau does not help to support our case, but our grammar would require the first analysis where the root vowel surface form is fully specified.

(76) cɨɨr + a > cɨɨrɨ: 'her head' (Case a.)

+hi -hi /cɨɨr + a/ +ba -rd	SPECIFY	MAX F
☞ +hi (cɨɨ)(rɨɨ) +ba -rd		*
+hi (cɨɨ)(rɨɨ) +ba -rd	*!	*
+hi (cɨɨ)(rɨɨ)	**!	***

We have now covered all but the very rare cases where this type of fronting and rounding does or doesn't take place. The grammar as shown in (72) is sufficient providing that we assume that /ɨ/ is underspecified for backness and rounding. (But note that surface [ɨ] may not be underspecified with this analysis.) This could be a problem for richness of the base, but it may be that the two words in case c. which don't undergo harmony when fronting and rounding is expected are demonstrating what happens when an underlying /ɨ/ is fully specified and therefore allowed to remain. I do not have enough words to explore this possibility, but it could provide another line of inquiry if more words were found in this category.

3.4.4 Fronting of central vowels in a foot

Now we consider the other type of fronting. In this case, both [ɨ] and [a] can be fronted:

(77) bɨŋ-ɛ > (bɨ̀ŋ̀ɨ:) 'to open', bal-ɛ > (bɛ̀lɛ̀:) 'to love'

It should be noted that this is not a case of total harmony (with ATR allophone differences). Feet containing suffixes do not always exhibit total harmony:

(78) bal-u > (bɨ̀lù:) *bulu 'love him'

In this example, the [a] vowel has been raised to ɨ, but not rounded to copy the [u]. This demonstrates that the process described in this section applies to fronting and not rounding. To cover the fronting harmony described here, We need the following constraint:

(79) ALIGN L FT [-back]: Within a foot, every [-back] specification must be aligned with the left edge of a foot.

The bottom candidate is ruled out because the suffix morpheme is not identifiable. The second candidate violates the ALIGN constraint which defines the domain of fronting harmony.

(80) *bal+ɛ> (bɛ̀lɛ̀:) 'to love'*

+ba -ba /bal-ɛ/	REALISE MORPH	ALIGN L FT [-back]	MAX F
-ba ☞ (belɛɛ)			*
+ba -ba (bəlɛɛ)		*!	
+ba (bəlaa)	*!		

This can be compared with the lack of fronting across a foot boundary, where the ALIGN constraint no longer applies.

(81) *baad + ε > (bàa)(dɛ́:) 'to wash'*

+ba -ba /baad-ε/	ALIGN L FT [-back]	MAX F
-ba (bεε)(dεε)		*!
-ba +ba (bεε)(daa)		**!
+ba -ba ☞ (baa)(dεε)		

Only unrounded vowels can be fronted, so we need the following constraint:

(82) $*\begin{bmatrix} +\text{ rd} \\ -\text{ ba} \end{bmatrix}$ to avoid front rounded vowels.

The ranking is:

(83) $*\begin{bmatrix} +\text{ rd} \\ -\text{ ba} \end{bmatrix}$ >> ALIGN L FT [-back]

(84) shows how this ranking causes front rounded vowels to be avoided.

(85) *gus + ε > (gùsí:) 'to buy' (height harmony assumed)*

-ba /gus-ε/	$*\begin{bmatrix} +\text{ rd} \\ -\text{ ba} \end{bmatrix}$	ALIGN L FT [-back]
-ba ☞ (gusii)		*
-ba (güsii)	*!	

3.4.5 Total Harmony

Total vowel harmony takes place across all vowels within the Prosodic Word, within the stem. Again I use an AGREE constraint as I can't actually be sure of the direction, (following the example of Padgett (2002)). This constraint is a cover constraint for ALIGN F L PRWD and ALIGN F R PRWD

(86) AGREE (F PRWD): If any segment is associated with F, then every segment in the Prosodic Word is associated with F.

I will assume, following Richness of the Base, that there is a disharmonic input:

(87) kɔ̄ɔmɔ̄m 'rat'

kɔɔmam	AGREE (F PRWD)	MAX F
☞(kɔɔ)(mɔm)		*
(kɔɔ)(mam)	*!	

The next case to be accounted for is when there is a stray syllable. Recall that the stray syllable is outside of the prosodic word, so constraints dealing with the prosodic word do not affect it. I will use the constraints we have already seen, but with a different result.

(88) gədàamɔ́ 'horse'

gidaamɔ	AGREE (F PRWD)	MAX F
☞(gədaa)mɔ		*
(gədaa)ma		**!
(gidaa)mɔ	*!	

The Prosodic Word can stretch beyond the root to include suffixes. These are not subject to total harmony however because REALISE MORPH is ranked higher than AGREE (F PRWD). MAX RT F is a positional faithfulness constraint that must also be ranked higher than AGREE (F PRWD) as we saw in (59).

We have already noted that when stray syllables become footed through the addition of the definite article -ŋ, that this does not cause total harmony to take place. The only way to deal with this is to say that the parsing and harmony occurs at lexical level and that the definite article addition is post lexical, at the phrase level.

So our grammar for the total harmony is:

(89) MAX RT F, REALISE MORPH >> ALIGN F L PRWD, AGREE (F PRWD) >> MAX F

This completes our OT analysis of Kera vowel harmony. In summary, our total ranking is as follows:

(90) *Vowel harmony grammar (highest ranked at top)*

	Motivated by tableaux:
undominated	
DEP F, SPECIFY, *[+rd,-ba], MAX [+hi]	56 66 67 68 73 74 75 76 85
↓	
height harmony	
AGREE MWD [hi]	66 67 68
↓	
positional faithfulness – suffix, fronting	
MAX [–hi], ALIGN L FT [-back], REALISE MORPH	59 66 67 68 73 74 75 76 80 81
↓	
positional faithfulness - root	
MAX RT F	59 73 74 75 76 80 81
↓	
epenthetic copy vowels, total harmony	
ALIGN F L PRWD, AGREE F PRWD	59 87 88
↓	
faithfulness – vowel	
MAX F	87 88

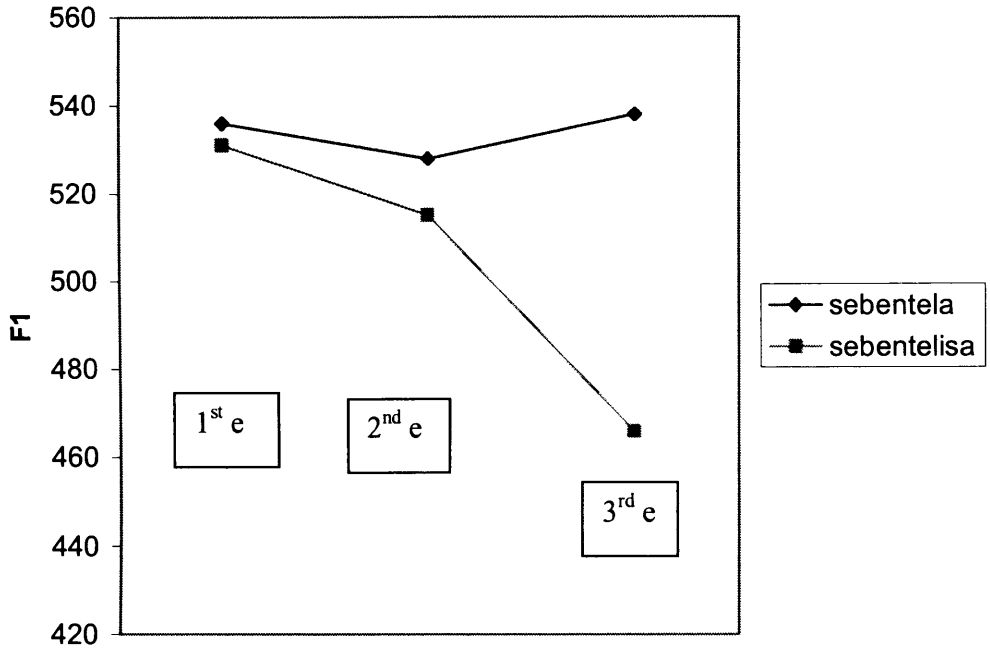
3.5 Acoustic measurements and discussion

3.5.1 Vowel harmony or co-articulation in Kera?

This chapter has assumed that we are dealing with vowel harmony and not just co-articulation. But it would be helpful to confirm the basis for this assumption. In words which exhibit total vowel harmony, it is not possible to give phonetic evidence to prove that this is vowel harmony as opposed to co-articulation or a chance similarity between the vowels. However, in polymorphemic words where the addition of a suffix causes a change of height in the vowel, we can compare the same root with high and low suffixes. If the root vowel were to change its quality because of co-articulation, I would expect the two vowels to start with the same formants and for the formants to move towards the suffix formants at a later stage. This is what takes place in Siswati. In (91), the Siswati speaker changes the quality of /e/ according to the following vowels, but not throughout the word. This looks

like co-articulation rather than height harmony despite the claims of some linguists. More details concerning the co-articulation analysis of Siswati can be seen in Malambe (2006).

(91) *Siswati data from Malambe (2006)*

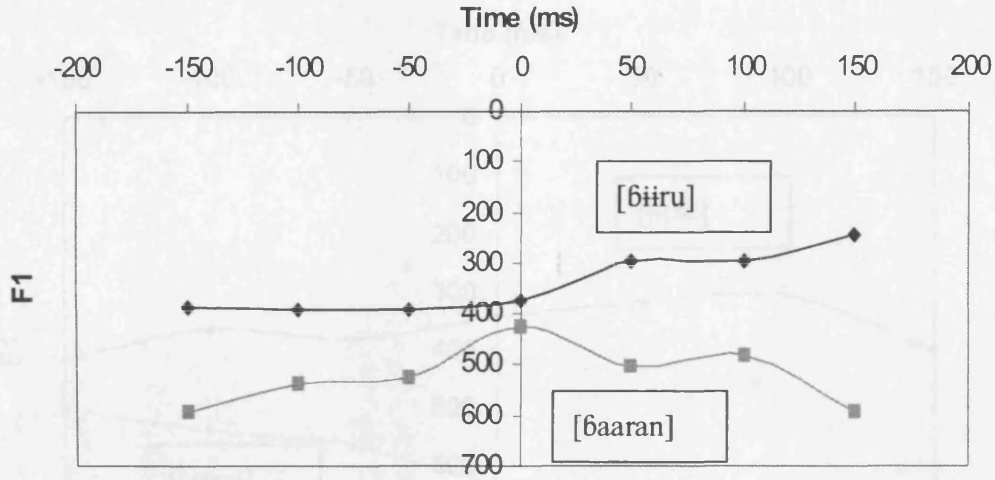


However, if there is real vowel harmony taking place, I would expect the first formant to be different throughout the word. This is what happens in Kera. In the example below, the F1 value for [ɨ] and [a] differs considerably at the beginning of the word. This is clearly not the same vowel with minor phonetic perturbations; it has become a different vowel.

(92) Height harmony in /a/ root vowel

/ɓaar-u/ [ɓ̃ɨɨrū:] 'diverge from him'

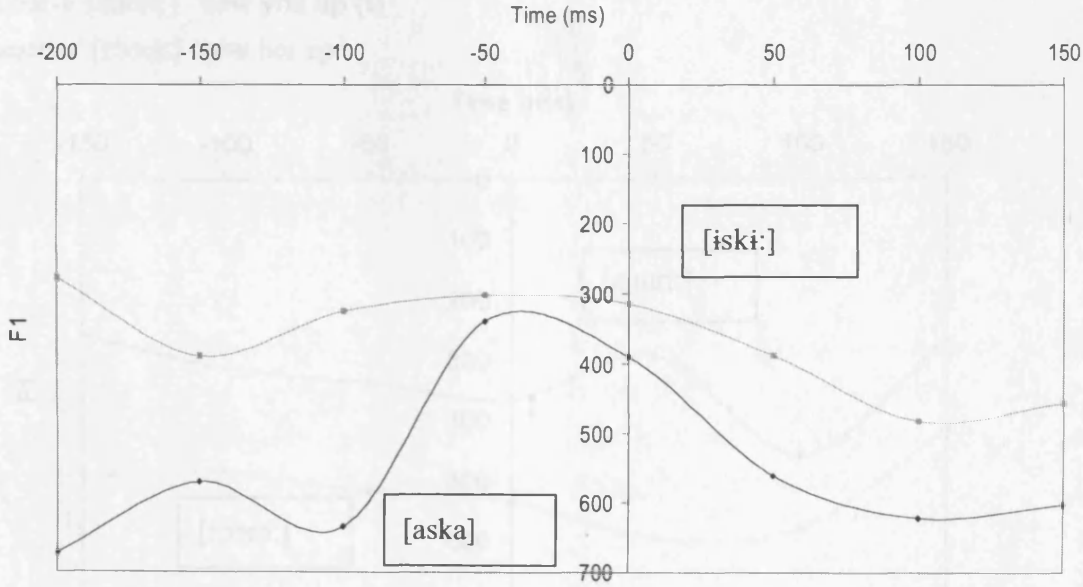
/ɓaar-an/ [ɓāarān] 'diverge from me'



The height harmony also occurs in the suffix, shown here with /a/ and /ɨ/ roots

(93) /aska/ [áská] '(a) fish'

/ɨsk-a/ [ɨskɨ:] 'understand her'

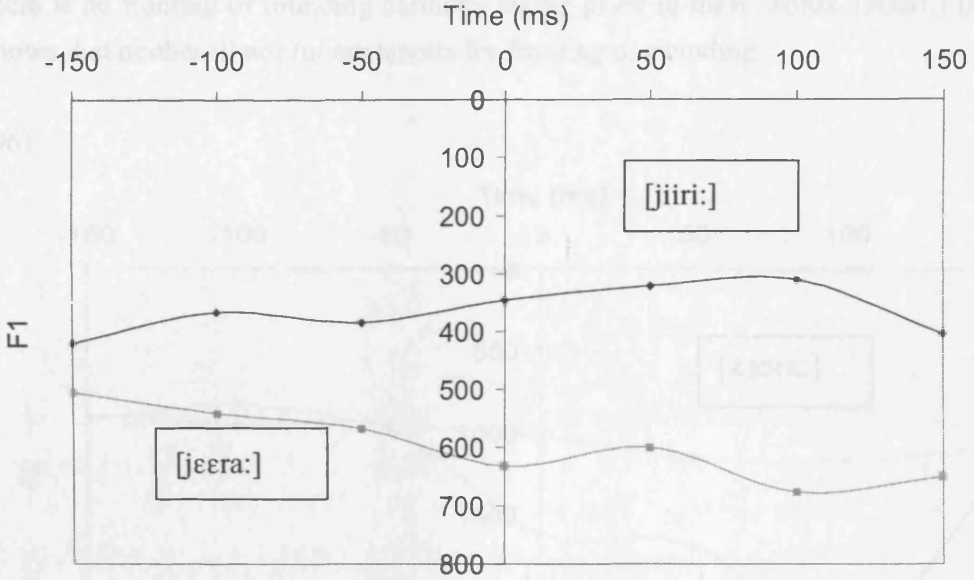


The same is true for the vowels /ɛ/ and /ɔ/. Even though the distance between the F1 values is less than for /a/, there is still a clear difference between the two vowels.

(94) /ɛ /

/jɛɛr-i/ [jîiřì:] 'write to you (f)'

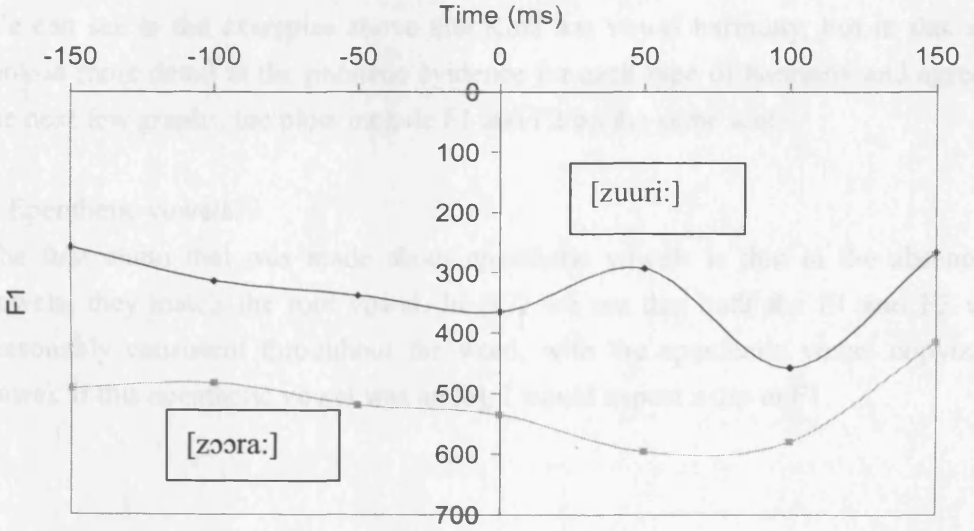
/jɛɛr-a/ [jɛ̀ɛrà:] 'write to her'



(95) /ɔ /

/zɔɔr-i/ [zùuřì:] 'sew you up (f)'

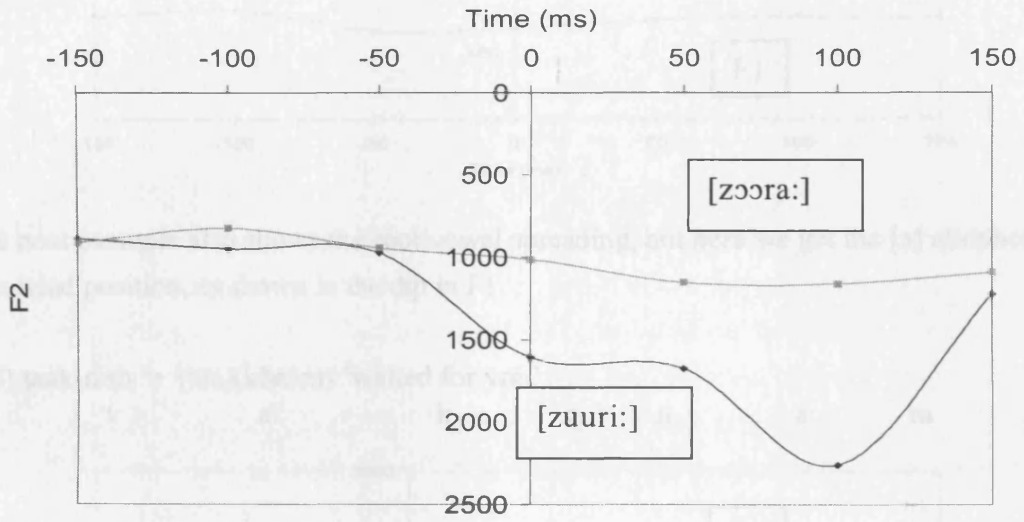
/zɔɔr-a/ [zɔ̀ɔrà:] 'sew her up'



These examples show clearly that the change in quality of the vowel comes about because of a vowel harmony process and not just a slight phonetic perturbation which would be limited to the last 50 ms of the vowel (Xu an Liu in press). That kind of a change can be seen in the F2 values for [zuuri:] and [zɔɔra:] in (96), where I expect no fronting or

rounding harmony. The F2 values for [u] and [ɔ] are essentially the same, but at 50ms before the start of the [r] consonant, the F2 values move towards the F2 value for the following vowel. Given that only back vowels are rounded in Kera, this graph shows that there is no fronting or rounding harmony taking place in these words. [zuuri:] in particular shows that neither /i/ nor /u/ are targets for fronting or rounding.

(96)



3.5.2 Examples of vowel harmony types

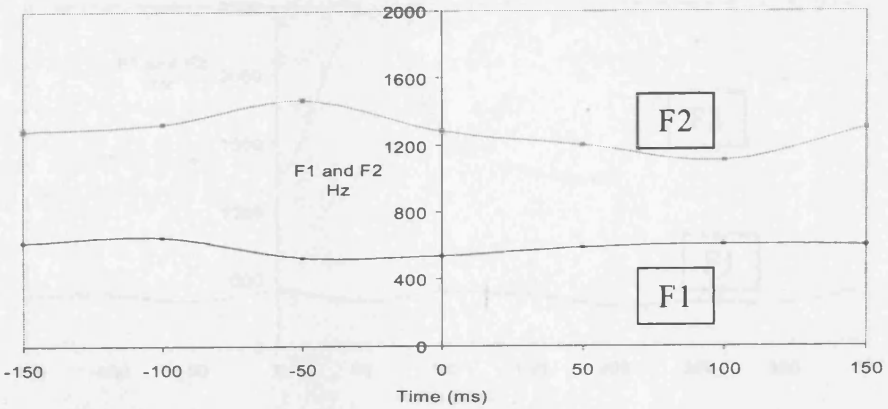
We can see in the examples above that Kera has vowel harmony, but in this section, we look in more detail at the phonetic evidence for each type of harmony and agreement. For the next few graphs, the plots include F1 and F2 on the same scale.

a. Epenthetic vowels

The first claim that was made about epenthetic vowels is that in the absence of other vowels, they match the root vowel. In (97) we see that both the F1 and F2 values stay reasonably consistent throughout the word, with the epenthetic vowel copying the root vowel. If this epenthetic vowel was an [ə], I would expect a dip in F1.

(97) taak-m > tāakām 'wait for you'

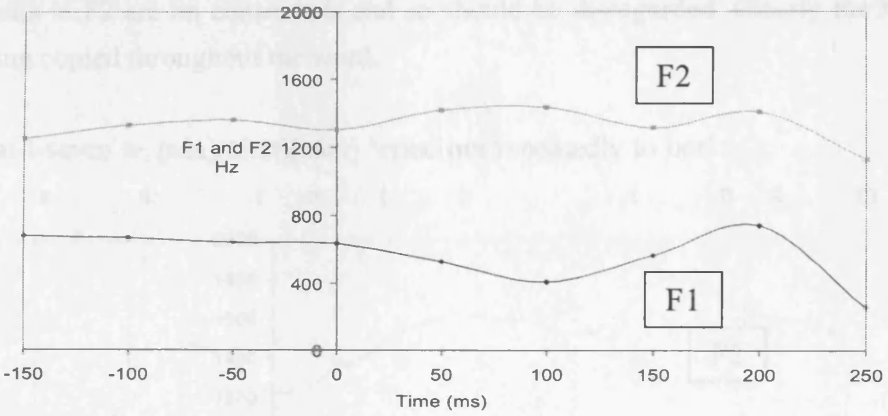
t a: k a m



The next example also shows the root vowel spreading, but here we get the [ə] allophone in non-head position, as shown in the dip in F1.

(98) taak-n-m > (tāa)(kənām) 'waited for you'

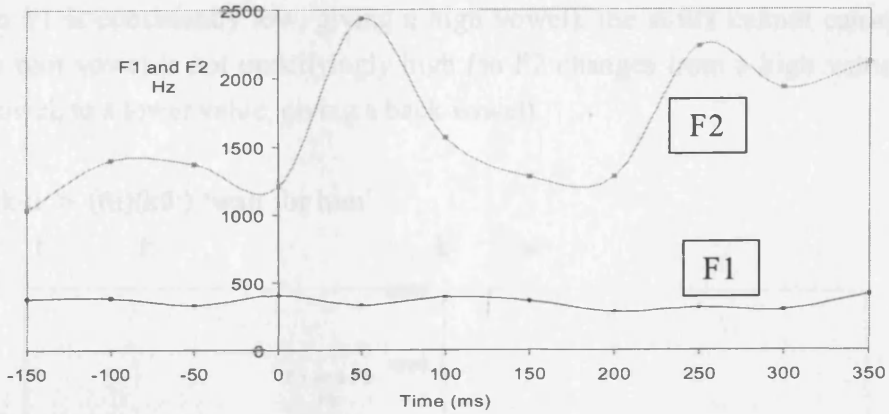
t a: k ə n a m



When the suffix is a vowel, it spreads as far as the root but not beyond. The next example illustrates that the position of the articulators is probably relaxed somewhat between feet, so that if there is a transition between [t] and [n], it has a schwa-like quality. But in this example, this transition should not be considered to be a moraic vowel. if it were, it would have the quality of [i].

(99) taak-t-n-i > (fɨɨ)(kīt)(nī:) 'waited repeatedly for you (f)'

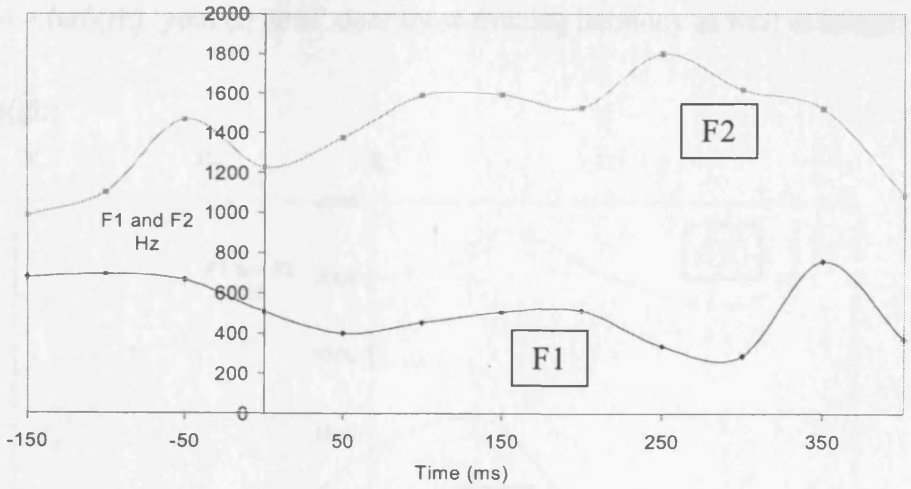
t ɨ: k i t n i:



We saw in chapter 2, §2.2.3.1, that non-head vowels tend towards a lower F1, but that F2 is not greatly affected by a shorter duration. The graph above suggests that for high vowels, the F1 value stays constant while F2 changes. We can compare this with another word with multiple suffixes, this time with non-high vowels. In this case there is considerable F1 fluctuation with the most schwa-like F1 value for the transition between the t and the n. The fluctuations in F2 are on consonants and so should be disregarded. Clearly the root vowel [a] is being copied throughout the word.

(100) saat-t-t-n-m > (sáa)(tə́tát)(nám) 'cried out repeatedly to her'

s a: t ə t a t n a m



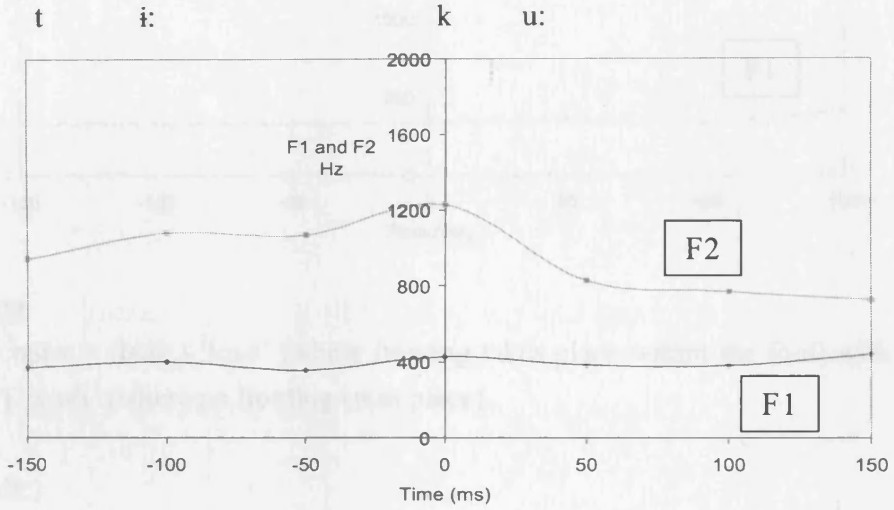
b Height harmony

We saw several examples of this in §3.5.1 above, so we will not repeat them here.

c. Fronting and rounding

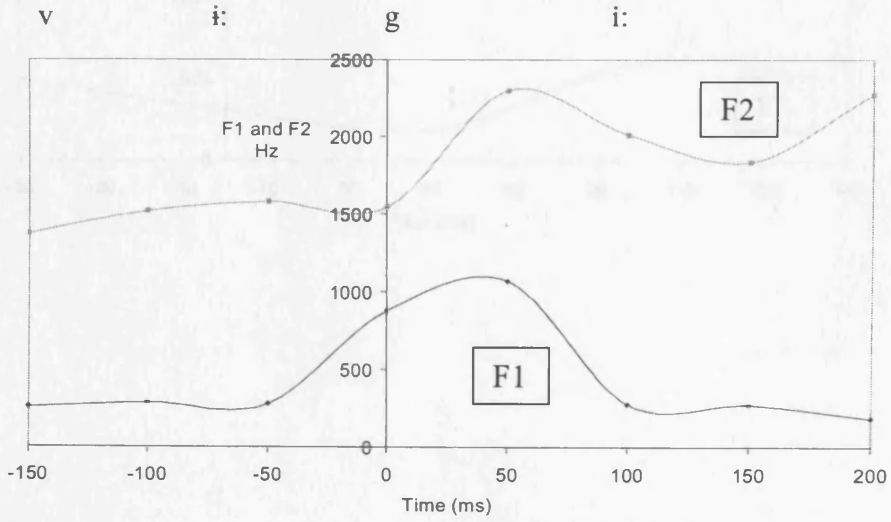
The next example confirms that although height harmony takes place between root and suffix (so F1 is consistently low, giving a high vowel), the suffix cannot cause rounding when the root vowel is not underlyingly high (so F2 changes from a high value, giving a central vowel, to a lower value, giving a back vowel).

(101) taak-u > (fɨɨ)(kū:) 'wait for him'

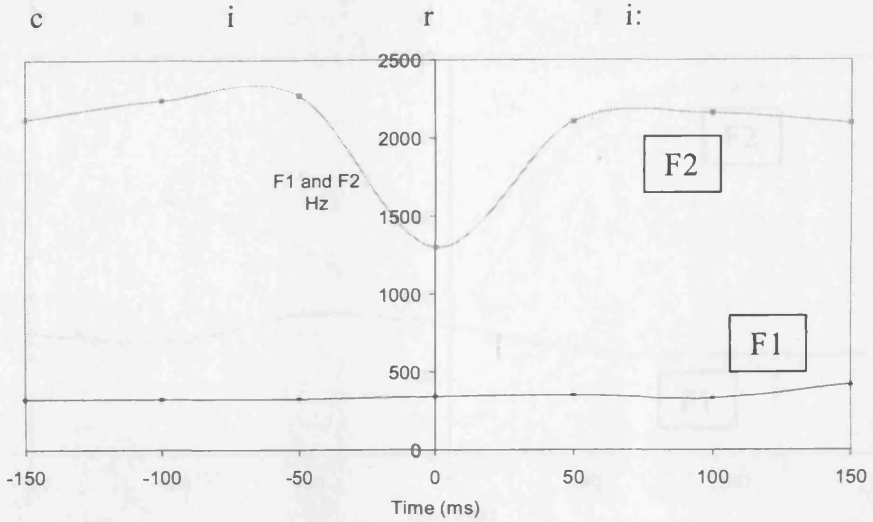


Both vowels must be high for this harmony. Therefore (102) vɨɨg-ɛ > (vɨɨ)(gi:) 'empty stomach (forgive)' does not harmonize and the F1 values are different. But it does show height harmony, so the f1 values are the same. In comparison, (103) cɨɨr-i > (cii)(ri:) 'your (f) head' does show fronting harmony as well as height.

(102) (vɨɨ)(gí:)



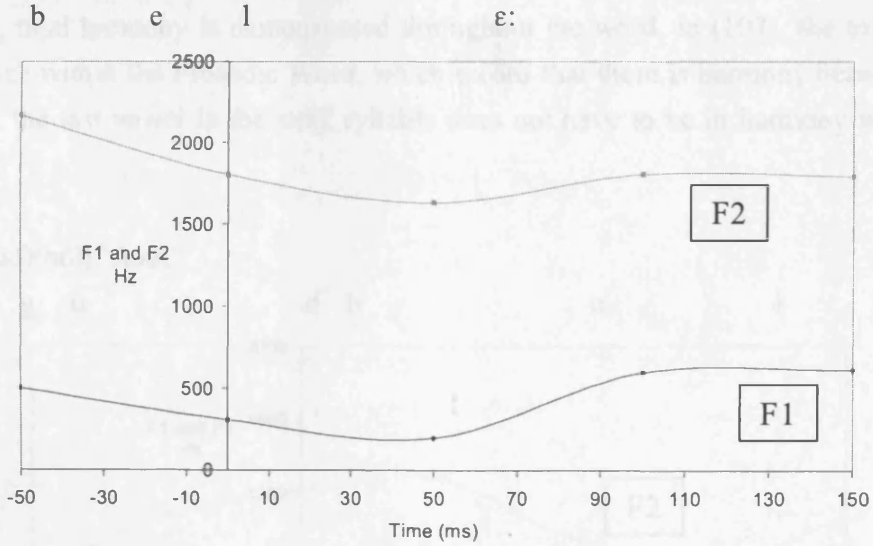
(103) (cīi)(rī:)



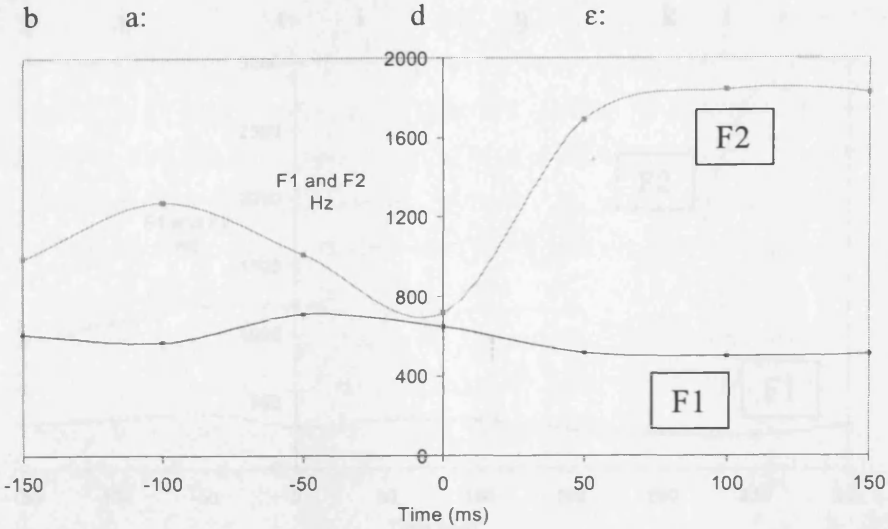
d. Fronting

Compare bal-ɛ > (bèlɛ̀:) 'love' (where fronting takes place within the foot) with baad-ɛ > (bàa)(dɛ́:) 'wash' (where no fronting takes place)

(104) (bèlɛ̀:)



(105) (bàa)(dɛ́:)

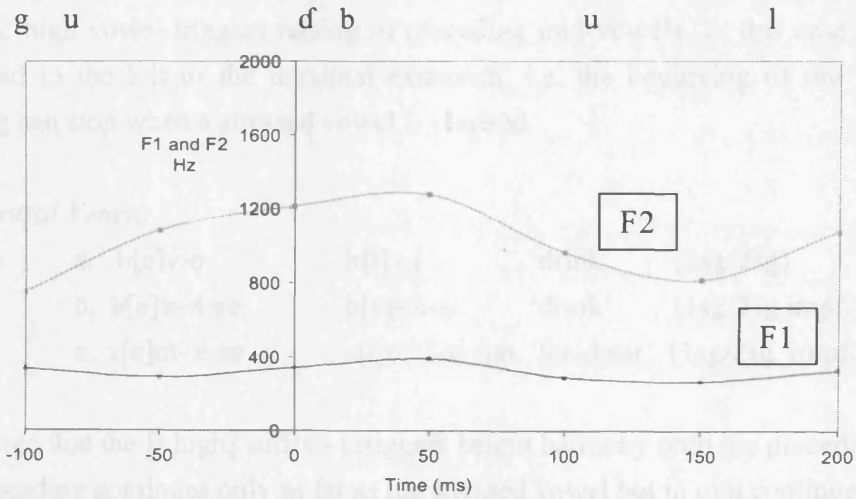


Clearly, the vowels of the first syllables of (bèlɛ̀:) and (bàa)(dɛ́:) in (104) and (105) are different from each other, and we are dealing with a categorical difference which is brought about by harmony operating in the first case and not the second.

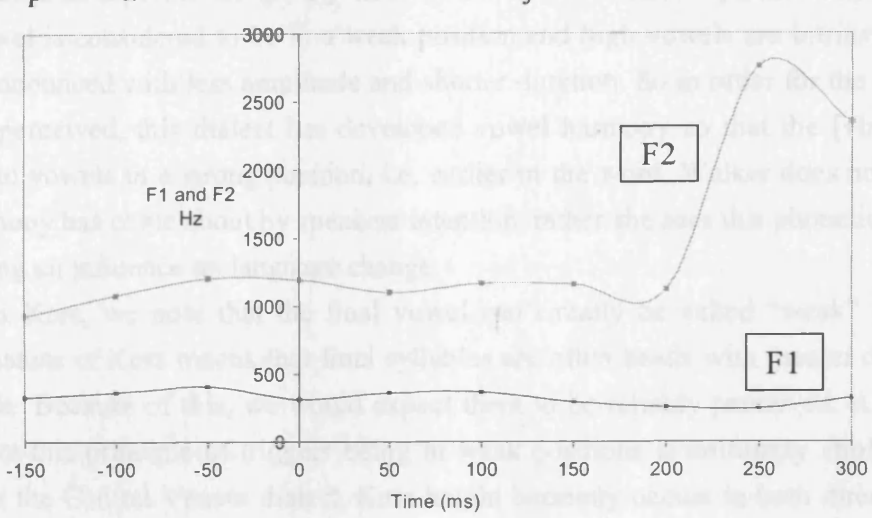
e. Total

In (106), total harmony is demonstrated throughout the word. In (107), the total harmony takes place within the Prosodic Word, which means that there is harmony between the two feet. But the last vowel in the stray syllable does not have to be in harmony with the root vowel.

(106) (gùd)(búl) 'stool'



(107) (pɨ̄)(rɨ̄ŋ)kí 'old man'



This concludes our discussion of the acoustic phonetics measurements for vowel harmony.

3.6 Motivation for vowel harmony in Kera

Kera has several types of vowel harmony and the motivation for all of them isn't necessarily the same. In most cases the suffix vowel is the trigger and the root vowel is the target. Walker (2005) would classify this as a vowel in a 'weak' position triggering a vowel in a 'strong' position.

(108) /baad-u/ bɨ̀ndù: 'wash him'

Walker discusses a situation such as this in the Central Veneto dialect of Italian where a post-tonic high vowel triggers raising of preceding mid-vowels. In this case the harmony can spread to the left to the maximal extension, i.e. the beginning of the word, or the spreading can stop when a stressed vowel is reached.

(109) *Central Veneto*

Compare	a. b[é]v-o	b[í]v-i	'drink'	(1sg/2sg)
	b. b[e]v- é-se	b[e]v-í-si	'drink'	(1sg/2sg impf. subj.)
	c. s[e]nt- é-se	s[i]nt- í-si-mo	'feel,hear'	(1sg/2sg impf. subj.)

In a) we see that the [+high] suffix –i triggers height harmony onto the preceding vowel. In b) the spreading continues only as far as the stressed vowel but in c) it continues beyond the stressed vowel to the left boundary of the word.

Walker claims that the motivation for this unusual kind of harmony is perception. If [+high] does not spread, the quality of the final vowel is hard to perceive. In Veneto, the final vowel is considered to be in a weak position and high vowels are intrinsically weak, being pronounced with less amplitude and shorter duration. So in order for the vowel to be reliably perceived, this dialect has developed vowel harmony so that the [+high] feature spreads to vowels in a strong position, i.e. earlier in the word. Walker does not claim that this harmony has come about by speakers intention, rather she sees this phonetic motivation as exerting an influence on language change.

In Kera, we note that the final vowel can't really be called "weak" because the iambic nature of Kera means that final syllables are often heads with greater duration and amplitude. Because of this, we would expect them to be reliably perceived. Also I cannot claim that this principle of triggers being in weak positions is uniformly applied because unlike in the Central Veneto dialect, Kera height harmony occurs in both directions, from suffix to root and from root to suffix. Walker's account would give no motivation for the spreading taking place from root to suffix. So this undermines our case for claiming that the motivation for harmony is the perception of the quality of the weak vowel.

However, we can still explore the possibility that some sort of perception is part of the motivation for harmony. When extensive vowel harmony occurs in a language, the number of possibilities of combinations of vowels diminishes considerably. This lightens the load in perception because as soon as the listener has perceived one vowel, he then has a good idea what to expect for the others. This has to improve the perception rate. With this in mind, we might ask why all languages do not exhibit total harmony. The answer to that is presumably that with total harmony, very few contrasts are possible and this limits the number of words that are possible. In a language like Kera where most words are disyllabic and complex onsets and codas are prohibited, total harmony everywhere might be too limiting on the range of possibilities for the lexicon. Nevertheless, Kera does make significant use of vowel harmony and therefore holds the two strands of ease of perception versus sufficient contrast in tension. In fact in Kera, the balance between these two strands differs depending on the phonemic level involved. At the level of the root, within the Prosodic Word, total harmony is exhibited, showing that ease of perception has prevailed. But when single-vowel suffixes are added, total harmony would severely reduce the understanding and the range of options for suffixes. The suffixes are triggers in all of the harmony types, but they can only be targets in height harmony so that sufficient material from the original suffix is preserved and identification of the suffix is not compromised.

Harmony provides cohesion for the prosodic and morphological units which are domains for the harmony. As each domain has a different type of harmony, the extent of the harmony is an indication of the boundary of the unit. This eases the parsing process.

Another motivation could be based on production. Certain sequences are easier to pronounce - eg *apa* is easier than *api* because the tongue doesn't need to move so much.

Consider: *waat-t-n-u* > *wīɨtūtnū* 'spoke to him repeatedly'. This word includes height harmony and filling in of the epenthetic vowels with the same features as the suffix. We could argue that by filling in the epenthetic vowel with suffix qualities, the perception of the suffix is made easier and that in any case, avoiding extra vowels eases the strain on perception. We could also say that the failure of total harmony marks the stem as *waat-* and the rest of the word as suffixes. The height harmony shows that this is all part of one Morphological Word. Finally, we could claim that the height harmony eases the amount of vertical movement of the articulators.

To summarise, the motivating factors for Kera harmony are likely to be: ease of perception, ease of production, and cohesion within units. As with Walker (2005), I do not claim that the harmony has developed from the intention of the speaker, but rather that diachronically, the drive for harmony and the opposite drive for sufficient contrast have both played a part in the development of the language. Harmony is used synchronically to discern the morpheme structure. This can be seen in the following pair where underlyingly there is the potential for confusion, but once height harmony takes place between the verb root and the suffix, the confusion is avoided.

(110) bàadù > (bàa)dù 'cat'
bàad-u > (bɨɨ)(dù:) 'wash him'

3.7 Literature on vowel systems and vowel harmony

This section aims at placing the Kera vowel harmony processes in context by looking at systems in other African languages, particularly Chadic languages.

3.7.1 Templatic systems

In templatic languages, the lexical root typically consists of just consonants. Then templates with combinations of vowels are used for tenses and aspects. There are often fewer vowels than slots, so the appearance is the same as if there is widespread total harmony.

Some of the patterns we have seen in Kera vowel harmony could be analysed with a templatic approach. This idea is seen in other Chadic languages including Hausa and Migaama, and it is well known in several Cushitic and Semitic languages. The following example from Yu (2005), with data from Newman (2000), shows that the class 5 plural in Hausa is formed by infixing the vocalic plural morpheme between the root-final consonant cluster; but if the root ends in a single consonant, as in (111b), the final consonant is duplicated. This looks like a hint of templatic style behaviour.

(111) *Hausa example of templates from Yu (2005)*

	sg.	pl.	
a. /gurb/	gurbìi	guràabuu	'hollow place'
b. /gaɓ/	gaɓàa	gaɓàaɓuu	'joint limb'

In Migaama (Roberts 2002), the case for a templatic approach is stronger. The verb forms consist of the base with suffixes added. The simple base and the imperfective base each have their own template, and the positioning of the consonants and vowels is affected by the number of root consonants. Glides are used as default consonants where necessary and [i] as default vowel.

(112) *Migaama example of templates from Roberts (2002), simplified*

Number of C	Root	Gloss	Base	Template	Surface form
1	t	'eat'	Simple	i CVCC-o t	tiyaw
			Imperfective	i + non-high V CVCVC:-a t	deewa
2	wg	'to pound'	Simple	a CVCC-o w g	waggo
			Imperfective	a CVCVC:-a w g	wagakka
3	msl	'be lost'	Simple	a CVCC-o m s l	mas(i)lo
			Imperfective	a CVCVC:-a m s l	masalla
4	krŋs	'chew on'	Simple	o CVC C-o k r ŋ s	korŋ(i)so
			Imperfective	o CVCVC:-a k r ŋ s	korŋossa

(113) *Classical Arabic examples* (McCarthy and Prince 1990a, McCarthy 1981, Yip 1988)
root [k t b], forms include: katab, ktabab, ktaabab, takaaab, utakaatab, tukuutib

In the case of Arabic, the templatic approach is clearly helpful. In the example above, [k], [t], and [b] are placed in the template first and then the vowels are filled in according to the slots available for the tense and aspect required. For Chadic languages, a templatic approach could be used, and some of the Chadic work on 'prosodies' (see 3.7.3) could relate to this, but the advantages of using this approach for a complete analysis of the vowel harmony facts is less clear. Nevertheless, the link with Semitic languages is evident and is not altogether surprising, as all of these languages are linked within the Afro-Asiatic language family, and many Chadic languages have contact with Arabic. Chadic vowel systems often involve only a small number of vowels with one root vowel plus other vowels introduced for aspect and object markers. It is probable that Kera could be analysed in a similar way.

3.7.2 The foot as a domain

Kera has the foot as a domain for vowel harmony. Most other references in the literature to the foot as a vowel harmony domain either redefine the foot to cover an unspecified number of syllables (Steriade 1981), or describe a harmony system across feet (Kaun 1995). Clearly the extended foot is not the same use of the word 'foot' and the spreading across feet is actually the domain of the Prosodic Word (in my terminology). There are also cases where one linguist has claimed the involvement of feet in a language, but then another linguist (e.g. Walker 1999 on Altaic languages) has argued against this analysis. Ascrea Italian (Archangeli and Pulleyblank 2007) still seems a genuine case, but there are few others. It would be interesting to investigate other Chadic languages for foot structure as some of them may show similar patterns to Kera.

3.7.3 Chadic prosodies

African languages are well known for having ATR harmony, but not Chadic languages. ATR is sometimes seen in allophones as we have seen in Kera, but vowels do not contrast according to their ATR value. However, a different kind of vowel harmony is quite common in Chadic languages. They have a tendency towards height harmony and also fronting and rounding. Within the circles of Chadicist linguists, any harmony is usually referred to by the term 'prosodies'. It is assumed that Proto-Chadic had only one vowel which was either present or absent in each slot within the template. So schwa is seen as 'a non-vowel' and [a] as 'a true vowel'. Then the processes of palatalisation and labialisation affect vowels and consonants. This meant that the central vowels can be fronted or rounded.

In the following diagram, Wolff (1981) describes what he calls the prosodic system within Chadic languages. [+y] represents palatalisation and [+w] represents labialization. In some Chadic languages only vowels appear to be affected by this and the result is a six vowel system as shown below which has been generated from a two or one vowel system. In other Chadic languages, the palatalisation and labialization processes can also be seen in modifications of certain consonants. In many Chadic languages, the glides –y and –w appear where a vowel might be expected. So for example in Kera, */fal-i / > filiy* rather than the expected **fili:* 'find you (f)'.[10]

(114) *The 'prosody system', based on Wolff (1981)*

	Ø	-a-
Ø	ə	a
[+y]	i	e
[+w]	u	o

As expected from a combination of these processes, several Chadic languages have five or six vowels. These are reduced to fewer vowels in certain circumstances.

(115) Proto-Hausa, Schuh (1984) and Newman (1979)

Initial position	Medial position	Final position
i	i/ii u/uu	i u
		e o
a	a/aa	a

(116) *Daba (Central Chadic), Ruth Lienhard (p.c.)*

Surface vowels:

i	y	ə	u
e	ø		o
ɛ	œ	a	ɔ

These vowels reduce to [i, a, ə] once 'palatalisation' and 'labialisation' effects are taken into account. Palatalisation marks dative and Labialisation marks accusative.

[10] In Kera, foot structure may be playing a role in deciding whether the glide is to be treated as + or – consonantal, with a disyllabic foot preferring the [+cons.] version as shown. In this case the vowel preceding the glide is then a copy vowel of the root and harmony processes do not occur in the way they would if the glide became the nucleus of the syllable with a [- cons.] status.

(117) *Giziga, Mofu-north, and Lame: Barreteau (1987)*

	Front	Central	Round
High	i	ə	u
Non-high	e	a	o

In some languages, these word level processes are still clearly visible, acting on consonants as well as vowels, for example in the Central Chadic languages Podoko and Daba, in which palatalization prosodies are combined with vowel harmony, causing certain consonants to be palatalized along with the vowels. Schuh (2002a) gives the following examples:

(118) *Podoko*

/a/ is realised as [ɛ] and /ə/ is realised as [i],
and alveolar consonants are palatalized,
so /baza/ 'to unearth' > [baza],
but with imperative palatalization > [bɛʒɛ]

Gude

/sə̀bá/ 'drive away' verbal noun: [sə̀bán]
directional verbal noun: [ʃìbán]
/tə̀l/ 'sew' verbal noun: [tə́lə̀n]
directional verbal noun: [tíɬʸán]
/də̀m/ 'enter' verbal noun: [də̀mə̀ná]
directional verbal noun: [gʸìmán]

For more discussion on these forms and the claim that palatalizaion works at word level, see Schuh (2002a). Sumray also gives indications of the links between the vowel quality and the preceding glides. There are 3 vowels, ə, ʌ, a. When combined with 'prosodies', the following syllables result:

(119) *Sumray: Barreteau & Jungraithmayr (1982)*

	Fronting		Rounding
	Cy-	C-	Cw-
ə	Ci	Cə	Cu
ʌ	Ce or Cyʌ	Cʌ	Co or Cwʌ
a	Cya	Ca	Cwa

More discussion of Chadic vowel systems is available in Jungwraithmayr (1971), Kraft (1981) (mostly phonetic), Wolff (1981) and Roberts (2001).

Kera does not show any clear palatalisation or labialisation effects occurring on consonants, and nor is it clear that there are any semantic links between the Kera –i and -u suffixes when compared with other Chadic languages, but palatalisation and labialisation effects occur in enough Chadic languages for us to say that it may have been taking place in Proto-Chadic or in the early stages of development into individual Chadic languages. This may be where the vowel harmony comes from.

3.7.4 Direction and dominance

There are several languages in the world that exhibit root dominance, with features spreading in both directions in Cupeño, Japanese and Russian (Alderete 1996, 2001). Affix dominance as we have seen in Kera is far less common, but Alderete (1999a, 2001) gives examples of dominant suffixes in a few languages including Japanese, and Walker (2001) discusses the case of Veneto Italian where harmony is triggered by a suffix vowel (as we saw earlier in this chapter). The reason that Kera favours affixes as triggers rather than roots may well be because of the need to preserve the information that is necessary to identify the morpheme. As suffixes often consist of just one vowel, these vowels are protected from too much change, so the more common pattern of root vowels spreading to affixes may be blocked.

Hyman (2002) discusses whether there is a right-to-left bias in vowel harmony. His conclusion is that there is, and that this bias comes from the combination of two factors: (i) Root-triggered vowel harmony on suffixes is derived from post-tonic reduction, where a vowel reduces to schwa and is then open to harmonic effects, (ii) All vowel harmony that does not owe its existence to reduction is anticipatory. These two factors combined together mean that prefixes are poor triggers and good targets, roots are very good triggers and bad targets and that suffixes are reasonable triggers and very good targets. The result is that harmony is common from suffixes to roots and from roots to suffixes and also from roots to prefixes, but not from prefixes to roots. So one of the two sources of left-to-right harmony is missing and this produces a bias for right-to-left. Hyman notes with reference to Hansson (2001) that consonant harmony may show the same preferences, implying that vowel and consonant harmony are not as far apart as we think. Kera does not have any vowel prefixes, so it is hard for us to verify these claims in Kera, but there does still seem to be a right-to-left bias in Kera.

Kera also has a feature dominant system in the height harmony. Van der Hulst & van de Weijer (1995) describe dominant systems involving ATR spreading. Interestingly for us, they state that they are not aware of dominant systems involving such features as [high], [low], [-back] or [round]. My claim is that Kera height harmony exhibits just such a

system with a dominant value of [+high]. The [+high] feature spreads right from root to suffix, but also left from suffix to root.

3.8 Conclusion

This chapter has highlighted certain aspects of Kera harmony that are unusual and which merit further research: (a) Vowel harmony operates over three different domains: the Morphological Word, the Prosodic Word and the foot, (b) [+high] spreads in a feature dominant system, (c) the foot structure has an important role to play in the harmony system, (d) the normal pattern of roots being the trigger and affixes being the target does not occur in Kera except in the bidirectional spreading of height harmony, but suffixes are triggers for all types of harmony, (e) the fronting and rounding harmony provides a case of Parasitic Harmony where the trigger and target must both be [+high].

We have explored an analysis of Kera vowel harmony within the framework of Optimality Theory, considering the five types of harmony or agreement: (i) Epenthetic vowel fill-in which takes features from right-to-left if possible, (ii) a feature dominant height harmony, (iii) a fronting and rounding harmony targeting just central vowels with both the trigger and target being underlyingly high, (iv) fronting within the foot and (v) total harmony within the stem.

The main focus of this chapter has been the interaction of vowel harmony with the metrical structure. The Prosodic Word and the Foot are both domains for harmony and they are dependent on the foot structure. The foot structure is therefore central to the domains of harmony. The motivation for harmony could come from a combination of three sources: the ease of perception, the ease of production and as a mark of cohesion for the various domains. It is clear that in Kera, the building blocks of the foot and the Prosodic Word have important functions, arguably as important as the syllable.

Chapter 4
Tone and foot interaction

4.1 Introduction

Kera tone is worth investigating for a number of reasons. Firstly, it has so-called "depressor consonants" and a rich history of a changing relationship with voicing. At some point in its history, Kera developed three tonal contrasts, but now, among town dwellers, the number of tones has diminished to two and there are signs that for some speakers, tone may disappear altogether. The speed of change is faster for men than women in the village, but faster for women than men in town.

Kera tone also undergoes spreading and this has been incorrectly cited as an example of long distance voice spreading. Because of the relationship between voicing and tone, the tonal facts must be taken into consideration before making any claims that Kera supports the case for the controversial claim of long-distance voice spreading.

Thirdly, Kera tone is linked to the metrical structure of Kera in an interesting way. In two syllable words, the tone bearing unit appears to be the syllable, and the metrical structure has no part to play in the tonal associations with syllables. However, in words with three or more syllables, the tone bearing unit is clearly the foot. At this point, the metrical structure is all important in deciding which syllables are associated with tones.

I will cover all of these topics in the next three chapters. In this chapter, after an overview of Kera tone, we will consider the phonological relationship of the tonal structure with the metrical structure. We will see that the tone bearing unit appears to change from the syllable to the foot depending on the context, and we will examine which tone melodies can occur within the domain of the foot. The analysis will be presented within the framework of Optimality Theory. We will also discuss the implications of what we find for theoretical issues concerning tone bearing units. At this stage I will focus on the phonological issues.

In chapter 5, we will consider the issues concerning the interaction of tone with voicing, with more attention to the phonetic details. After an examination of tonogenesis in other languages, we will look carefully at the perception and production of tone in different Kera locations, with empirical evidence from experiments. We will see that location and gender both significantly affect the results. The sociolinguistic issues that arise from these results will also be discussed.

In chapter 6, I will discuss the claims that Kera has voicing spread, and we will see the evidence against this claim. I will also combine phonological analysis with phonetic findings to examine which of the available models of laryngeal features best describes the

Kera tone and voicing facts. There will be further remarks on how this relates to the foot structure and to the tone spreading rules in the presence of suffixes.

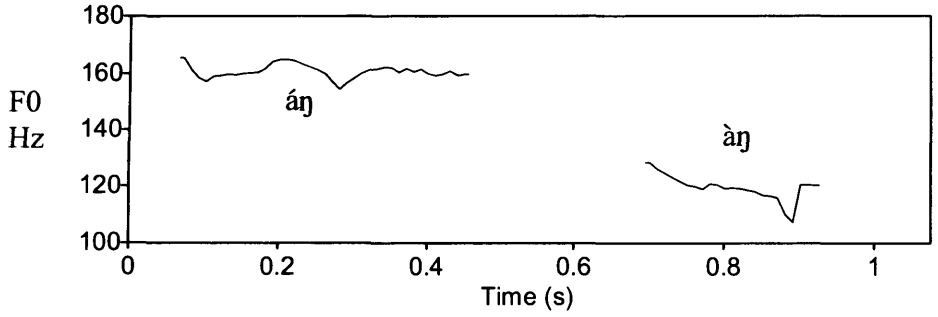
I will begin with an overview of the Kera tonal system. For the rest of this chapter, the claims will be based on the dialect of Kera which is spoken by men born and brought up in a village location, who then moved to town as adults. Throughout this thesis I am treating this as the standard Kera dialect (elsewhere called 'Village/Town Men'). The examples of spectrograms and pitch tracks are all taken from recordings of this dialect. In chapter 5 we will see why it is important to make this distinction.

4.2 Basic facts of Kera tone

Schuh (2003) claims that all Chadic languages are tonal. Kera is no exception with three tones, /H/, /M/, and /L/.[1] The three way contrast can be seen in the following minimal pairs from Pearce (2006a).[2] [3]

(1) *Minimal pairs for tone*

H	áŋ	'us (inc)'	163 Hz
L	àŋ	'you (pl)'	119 Hz

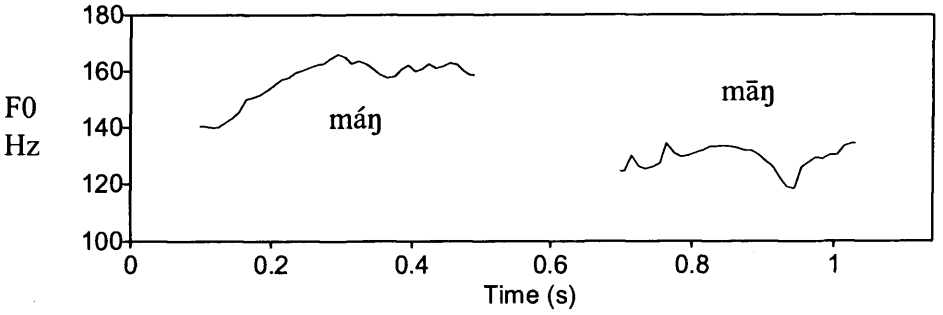


[1] In certain types of analysis, the M tone can be considered to be the default tone, where tone is unspecified, but as this depends on the model used for analysis and the form of storage for the lexical item in the lexicon, I will at this stage refer to /M/.

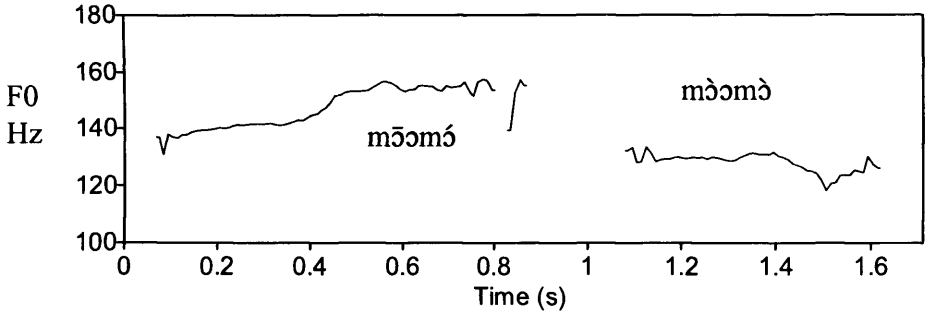
[2] These pitch tracks show the words recorded in isolation to emphasize the contrast, but they were also measured in tone frames with similar results. The measurements given here are for the F0 value in the middle of the vowel once the pitch track has reached a plateau. Care was taken to avoid the nasals as these tend to perturb the F0 value downwards.

[3] A number of the diagrams and examples in this chapter have also appeared in Pearce (2006a)

H	máŋ	'now'	163 Hz
M	māŋ	'close by'	133 Hz



MH	mɔ̄ɔmɔ́	'grandmother'	141, 156 Hz
LL	mɔ̀ɔmɔ̀	'spirit'	130, 126 Hz

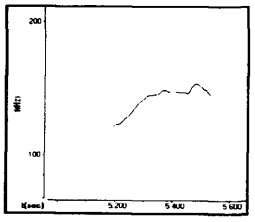


In nouns, we find seven possible melodies. These are illustrated below in words containing no obstruents. In the pitch tracks, the majority of H tones appear to be a MH rise. Yet phonologically, Kera has no contour tones. The apparent contour here is a phonetic effect from the sonorants (particularly nasals) which take longer to peak to the level of the target F0.

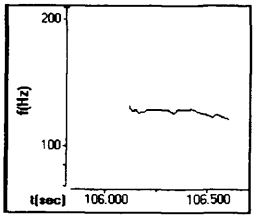
(2) *The tonal melodies on nouns containing sonorants, with pitch tracks*

[H]	mɔ́yán	'river'	[L]	hɔ̀ynà	'type of spirit'
[M]	māanɨ̄	'co-wife'	[LH]	hùɗúm	'hole'
[MH]	māahúr	'flute'	[HL]	mánhɔ̀r	'ten'
[HM]	máalāŋ	'bird of prey'			

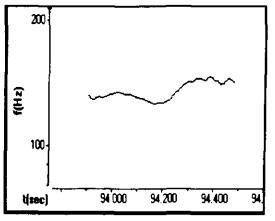
[H] <u>mɔ́yán</u>
141 146 Hz



[M] <u>māanɨ̄</u>
121 120 Hz

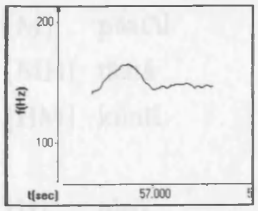


[MH] <u>māahúr</u>
129 145 Hz



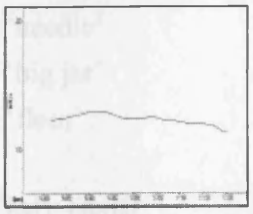
[HM] máalāŋ

157 136 Hz



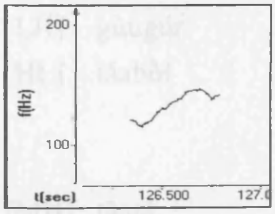
[L] hɔ̀ynà

120 119 Hz



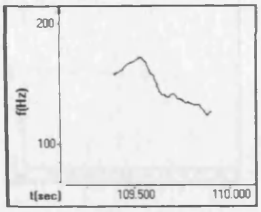
[LH] hùɗúm

111 137 Hz



[HL] mánhɔ̀r

163 127 Hz



There are two patterns that we might expect to see, but don't. These are [LM] and [ML]. It is not clear why this is the case, although it could be that historically L spread onto M syllables in both directions. If M is taken as the default tone, this is not a surprising process, but any explanation would have to explain why [MH] and [HM] still exist as I would then expect H to also spread onto M. Unfortunately, I do not have data from any older form of Kera, so any explanation would be speculation.[4]

4.2.1 Consonants and tone interaction

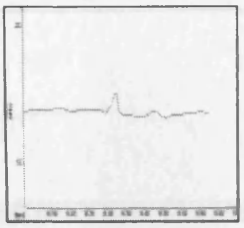
The seven melodies given in (2) also occur in words with obstruents. These are given in (3) using the following orthographical convention for voicing: A short VOT is written as a voiced obstruent while a longer VOT is written as a voiceless obstruent. Observe that 'voiced' stops correspond to L tone (in the right-hand column) while 'voiceless' stops correspond to M or H tone.

[4] We will discuss in chapter 5 how Town Men are losing the contrast in F0 between M and L. This could give us the alternative explanation for the loss of [LM] and [ML]. The disappearance of these patterns could be quite recent and due to the loss of contrast between M and L. But if this were the case, we would still expect to see these patterns among village speakers who have three clear tonal contrasts. The author is not aware of the existence of any such examples.

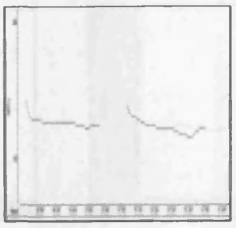
(3) *The tonal melodies on nouns with obstruents, with pitch tracks*

[H]	túrtí	'boat'	[L]	dàygà	'jar'
[M]	pāatāl	'needle'	[LH]	gùugúr	'chicken'
[MH]	tāatá	'big jar'	[HL]	táabùl	'table'
[HM]	kúntī	'flour'			

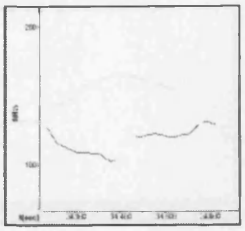
[H] túrtí
130 127 Hz



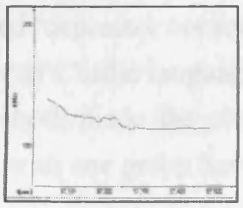
[M] pāatāl
120 117 Hz



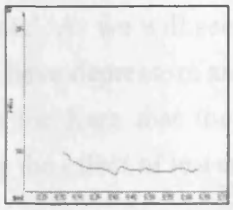
[MH] tāatá
110 118 Hz



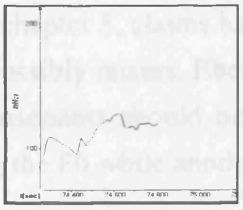
[HM] kúntī
126 110 Hz



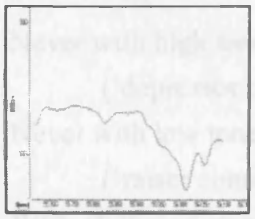
[L] dàygà
93 92 Hz



[LH] gùugúr
103 123 Hz



[HL] táabùl
129 99 Hz



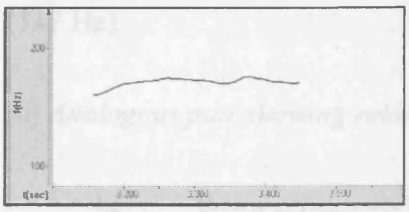
The relationship between voicing and tone applies equally to verbs, which have the surface melodies H, M, L, LH. As with the nouns, all of the patterns are attested with both sonorants and obstruents as illustrated below. Again, the voiced obstruents co-exist with L.

(4) *The tonal melodies in verbs, with pitch tracks*

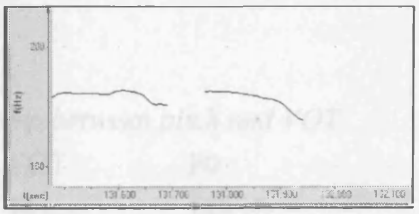
	sonorants		obstruents	
[HH]	lóɓɔ́y	'convince them'	fīlɨ́y	'find them'
[MM]	nīɨlīy	'chat to them'	kīyīy	'help them'
[LL]	nìlì	'surprise them'	ɟ̰iirì	'write to them'
[LH]	lòɓɔ̀y	'fatten them'	ɟ̰ɪɓrì	'listen to them'

The four melodies are shown below:

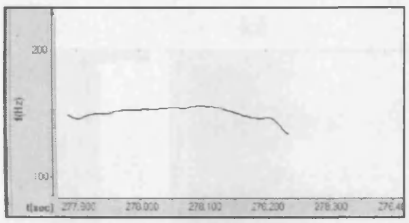
[HH] fɨlɨ̌y



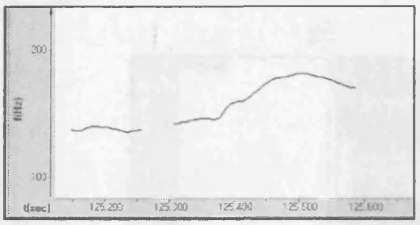
[MM] ɪ̄nɗɨ̄y 'lose them'



[LL] duuri 'fight them'



[LH] ɟ̃ɪ̌ɓrí



The relationship between L and voiced obstruents leads us to suppose that Kera may have so called 'depressor consonants'. As we will see in chapter 5, claims have been made that a number of Chadic languages have depressors and possibly raisers. Ebert (1979) and Pearce (1999) both made the claim for Kera that the consonants should be grouped into three groups with one group having the effect of lowering the F0 while another raises the F0.

(5) *Traditional grouping of Kera consonants*

Never with high tone: b, d, j, g, v, z
('depressor consonants' in Ebert 1979, Pearce 1999)
Never with low tone: p, t, c, k, f, s
('raiser consonants' in Pearce 1999)
With all three tones: m, n, ŋ, l, r, ɓ, ɗ, h, ʔ
('neutral consonants' in Pearce 1999[5])

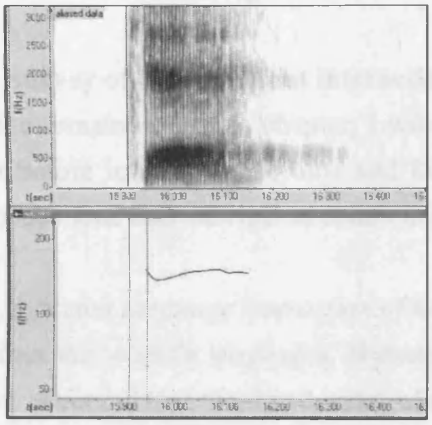
[5] Implosives and fricatives have sometimes been placed in different groups in the literature, but the grouping here reflects the correlation between tone and consonants as seen in the data collected for this thesis, including a lexicon of over 4000 words. Although fricatives have a durational contrast rather than a voicing contrast, the duration has the same connection to F0 as is found in the VOT value of stops. So fricatives of longer duration are never found with L tone. Odden (2005) notes that implosives are generally not depressors, as seen in Suma, Sayanci, Ngizim, Mulwi, Miya, Podoko, Dagare, Ebrie, Yaka, Zina Kotoko and various Southern Bantu languages. This raises the question as to whether the 'depressing' factor is really [voice]. These issues are discussed further by Ohala (1973), Hombert et al. (1979), Bradshaw (1999), and. Odden (2005).

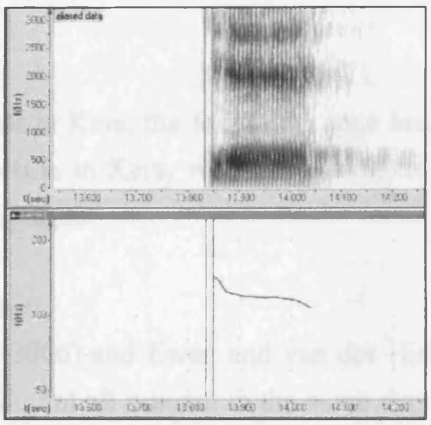
In the following analogous pair, we see that the VOT of the word-initial consonant is longer (34ms) before a high F0 value (149 Hz) and shorter (19 ms) before a low F0 value (117 Hz).

(6) *Analogous pair showing relationship between pitch and VOT*

		VOT	F0
kɛ́	'throw repeatedly'	34 ms	149 Hz
gɛ̀	'throw once'	13 ms	117 Hz

kɛ́ gɛ̀



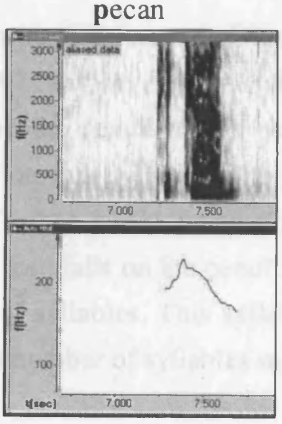


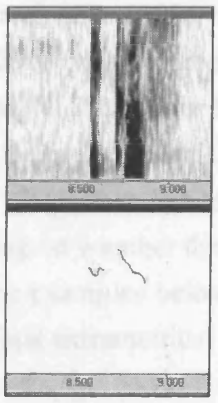
There is a similar pitch perturbation in English following voiced and voiceless obstruents, but generally the difference is only 5-15 Hz (as illustrated in (7) (Hombert et al, 1979)), compared to a difference of 20-60 Hz in Kera (shown in (6) and in several graphs in chapter 5).

(7) *Pitch perturbation caused by VOT difference in English*

	VOT	F0
pecan	42 ms	193 Hz
because	8 ms	179 Hz

pecan because





English has evidently not developed into a tonal language; but Kera, like all other Chadic languages, has developed a tonal system. And we have seen that Kera shows some sort of relationship between voicing and tone. In the next chapter, we will explore this in more detail and we will discuss the processes through which tone can develop, collectively known as 'tonogenesis'. But for the rest of this chapter, I will focus on the relationship between Kera tone and the foot structure. The main focus of this introduction to Kera tone is that even though there is a relationship between voicing and tone, the sonorant-only words show us that speakers of the standard Kera dialect have a three way contrast of tones regardless of the voicing.

4.3 Survey of tone and foot interaction

In the remainder of this chapter, I will show that in Kera, the foot is the tone bearing unit. But before looking at the tone and foot interaction in Kera, we will investigate the links between tone and metrical structure in other languages.

4.3.1 Across language interaction of tone and feet

Across the world's languages, Hyman (2001a, 2006) and Ewen and van der Hulst (2001) have observed that tonal and metrical systems do not all interact in the same way. We will consider just a few of the systems of interaction, concentrating on those that are relevant to Kera or other Chadic languages.

A common pattern is for heads of feet to attract tone. In Winnebago (Hayes 1995) the alternating stress pattern shows that each word is parsed into iambic feet and a tone is placed on the head of each foot. The leftmost foot takes the main stress. The first syllable is taken to be extrametrical.

(8) *Winnebago (Hayes 1995)*

<ha> (kiní) (jikshà) na 'he pulls taut'

A similar pattern occurs in Digo (Kisseberth 1984), Creek (Zec 1999), Setswana (Chebanne et al. 1997) and several other Bantu languages (Yip 2002), where prominence is generally placed on the penult and is realised by increased length. If the word has a lexical H, it surfaces on this syllable. The penult is analysed as being the head of the head foot. In Seneca (Prince 1983), parsing into iambic feet takes place from left to right. The head of the final foot falls on the penult or antepenult depending on whether there is an odd or even number of syllables. This syllable takes a H tone. The examples below show how an odd and even number of syllables might be parsed with a final extrametrical syllable.

(9) *Seneca (Prince 1983)*

stress on penult	(a.ge)(ga.yé')<oh>	'I'm willing'
stress on antepenult	(a.ge)(ni.yás)da<ye'>	'I have it on me'

Some Chadic languages also show H tone being attracted to heavy syllables. In Lagwan (Ruff 2005, p.c.), as in many Central Chadic languages, there are very few vowels with [a] having a major role, and [ə] considered to be a weak or non-vowel. In a sample of 240 verbs, 10% of verbs have underlying tone. For the rest, the tone is predictable. The initial syllable takes H and all other syllables take L, except when there is an initial consonant cluster or a light syllable with a weak vowel as found in Cə̀.C... In these cases, all tones are L. In the following CV structures, v represents a vowel other than [ə], usually [a].

(10) *Lagwan (Ruff 2005)*

Cə́C.Cv̀.CCv̀	/bə́rbàlʒà/	'write'
Cv́.Cv̀C	/ɬábàl/	'destroy'
CCv̀.Cv̀	/s''ᵊwàrà/	'squat'
CCə̀.CəC	/n̩dəbər/	'stagger'
Cə̀.Cə̀	/ʁə̀gə̀/	'close'

Ruff argues convincingly that the first consonant in a cluster should be considered extrametrical with evidence from reduplication. In any case, this consonant cluster blocks the H tone. H tones appear on heavy first syllables or CV syllables with a strong vowel whether light or heavy. The implication is that the syllable [Cə] cannot be a head and that first syllables which are heads attract H.

The heads of feet may also protect tones from deletion. When the tone survives on the head of the foot, tones on non-heads can be deleted. In Shanghai, each syllable has its own underlying tone, but non-head tones are deleted while tones are retained on trochaic heads. This applies to disyllabic or trisyllabic feet (Duanmu 1997; Yip 2002). When a tone is placed on the head of a foot, it is also common for this tone to spread onto the non-head. With the non-head tones deleted, head tones in Shanghai can spread to non-heads. This also applies to contour tones as seen in the following examples from Zhiqiang (2005)

(11) *Shanghai (Zhiqiang 2005)*

HL + T > H + L	thi-tshi	'weather'
	HL-MH > H-L	
MH + T > M + H	hut-shi	'anger'
	MH-MH > M-H	

A similar process takes place in Llasa Tibetan (Duanmu 1992, 1993) and Yoruba ideophones (Awoyale 2000). For these languages, the tone bearing unit (TBU) is the foot. I will be claiming that the TBU in Kera is also the foot, but Kera is different from languages such as Shanghai. In Shanghai, the number of tones either equals or exceeds the number of syllables and a number are deleted till the foot has just one tone. In Kera, the number of tones associated with a word is equal or lower than the number of syllables. Tones are not deleted, and if possible, they migrate so that each foot has just one tone.

In some languages, instead of tones being attracted to foot heads, foot heads can be attracted to tones. Usually heads are attracted to H (and non-heads to L). Examples of languages that function like this are Ayutla and Fuqing (Jiang-King 1996; de Lacy 1999, 2002b). In other languages, including a number of Chadic languages, certain tonal patterns are associated with certain foot types. In Bole verbs (Newman 1972), monosyllabic feet have low tone, while disyllabic iambic feet have H tone. In Kanakuru (Newman 1972) verbal nouns, a H tone corresponds to a light syllable, while a HL pattern associates with a heavy first syllable. Similarly, Bambara associates H or LH to the foot (Leben 2001, 2003). In Tangale (Kidda-Awak 2003), L verb roots have a strong tendency towards being heavy while H roots have light first syllables. This pattern does not continue beyond verbs and can be overridden by spreading of tones from suffixes.

Intonation in non-tonal languages such as English can also show a pattern where H or L tone is attracted to stress. In this case it is usually the main stress in the utterance rather than in a disyllabic foot, but in essence, it is the same type of relationship.

4.3.2 Interaction of tone and feet in Chadic languages

We now concentrate on traits that are particularly prevalent in Chadic languages. Several Chadic languages have been described as pitch accent languages. The implication of this description is that the language has a relationship between the tone and stressed syllables. Masa (De Dominicis 2003; Barreteau 1995), Mofu (Barreteau 1995), Mukulu (Roberts 2000) and Migaama (Roberts 2005) have been described in this way. In Migaama verbs, the H tone generally occurs on the first heavy syllable of the word. In long verbs, the placing of the H and L tones is predicable, but shorter verbs have contrastive tonal melodies. Throughout the language, the second syllable is often long, implying the possible presence of an initial iamb.

Apart from the cases already described, there is a limited amount of data concerning metrical structure and tone in Chadic languages. This may imply that there is no relationship of this nature in most Chadic languages, or it could be that there is simply a lack of detailed acoustic evidence concerning these languages. However, even without an overt discussion of foot structure, Newman (1972, 2000), Roberts (2001), Wolff (2001) and

Jaggar and Wolff (2002) do refer to quantity sensitivity and tone. For example in Hausa plural nouns (Newman 2000, Leben 1997, 2001), each class has certain limitations on the tone patterns and on the syllable structure. The syllable weights are always the same within each class. For example, class 5, as classified by the melody aaCuu, is always a light-heavy foot followed by a heavy foot, e.g. (dúwàa)(tsúu). In all classes, the last syllable is heavy and often the penult too. The following examples of the plural classes show that weight certainly plays a role in Hausa, and probably feet too. The tone associates from right to left, associating one tone with each syllable and then the leftmost tone spreads. The foot structure in the plural column is my addition, and not necessarily agreed upon by Newman or Lahrouchi 2005. In the 'weight' column, 'h h' means the final two syllables must be heavy. (This chart omits the classes 12-15 which are reduplicated forms.)

(12) *Hausa plural nouns, based on Newman (2000), Lahrouchi (2005) and reproduced in Pearce (2007a)*

class	tone	final Vs	weight	sg	pl	gloss
1	H	-oXi	-hh	ƙáagúwáa	(ƙáa)(gúwóo)(yîi)	'crab'
2	LH	-ai	-h	ɗǎaɓîbîi	(ɗǎa)(ɓîbái)	'student'
3.	HLH	-aXe	-hh	gárkáa	(gáràa)(kée)	'enclosure'
4	HLH	-Xa	-hh	mánòomîi	(mánòo)(máa)	'farmer'
5.	HLH	-aXu	-lhh	dúutsèe	(dúwàa)(tsúu)	'jungle'
6.	HL	-uXa	-h	gáatáríi	(gáa)(túràa)	'axe'
7	LH	-aXi	-h	góonáa	(gòo)(nàkîi)	'farm'
8	HLHH	-aXi	-hXh	gányée	(gán)(yày)(yákîi)	'leaf'
9	LH	-u/-i	h	bùkáatáa	(bùkàa)(túu)	'need'
10	XH	-	h	zúmùu	(zúmái)	'friend'
11	XH	-awa	hh	bàdùukùu	(dùu)(kàa)(wáa)	'leather worker'

X indicates an unspecified consonant (or custer) or an unspecified tone.

This table shows that tone, weight and vowel quality are all important in forming Hausa plurals. However, it does not follow from this that tone and feet are necessarily related. In fact, we can see that tones spread beyond foot boundaries and more than one tone can occur in one foot. It appears that heads can have H or L tone. What we can say is that the plurals seem to be made up of feet with an iambic structure, but outside of the plurals, other non-iambic structures are permitted. A further claim about tone and feet in Hausa has been made by Leben (1997, 2001). In loanwords from English, Leben remarks that Hausa constructs a maximally bisyllabic foot starting on the syllable that bears main stress in English and H is placed on the stressed syllable followed by L.

(13) *Hausa loan words (Leben 1997, 2001)*

(gwámnà)	'governor'
gàrà(tíi)	'guarantee'
(tân)(kíifàa)	'timetable'

However, Leben's 'tonal foot' is not affected by weight and therefore should not be confused with the iambic metrical foot as seen in the data from Newman (2000). Leben is dealing with a different issue.

This brief survey shows us that there is some precedent for tone languages having a metrical structure and for a link between tones and feet. We have also seen that in Chadic languages, there are signs of quantity playing a role in tone placement, but there is also a great variety in the way Chadic languages exhibit this relationship and Kera appears to be unique in having semi-independent systems which interact only in long words. We turn now to examine the Kera tone and foot interaction in more detail.

4.3.3 Kera Tone and Foot Interaction

Kera clearly has an active metrical structure which interacts with the tonal system. The placement of tone is partially dependent on metrical structure, but tone does not dictate the foot shape. When a word consists of exactly one foot, each syllable can carry a tone, but in words with two feet, each foot can only have one tone. Recall that in chapter 2 we saw that Kera has iambic feet constructed over light and heavy syllables: (∪ –) or (–). There are no (∪ ∪) feet.

Despite the fact that Kera monomorphemic words exist with four syllables, there are no examples of monomorphemic words with more than two tones. This could be because of a constraint on the number of tones at word level or it could be simply the accidental result of Kera words being generally too short to have three tones. We will see later that words with three tones would need to contain three feet. There are probably only two or three monomorphemic, non-compound words of this length in Kera and they happen not to have three tones. Reduplicated words such as *akɔ́lɓɔ̄ykɔ́lɓɔ́y* 'grasshopper' suggest that compound words can have more than two tones. This would imply that the two-tone restriction is not on the tone melody but rather on the normal length of a word.

There are no contour tones in Kera. If two tones are associated with one syllable, one of them will be deleted. Examples from natural speech suggest that the second tone is deleted with the vowel or maybe that the H tone deletes. Unfortunately, evidence is only available for the LH pattern:

(14)	Phrase final:	bègɛ́: 'animal'	hàgɛ́: 'cry'	gùní: 'wake'
	Phrase medial:	bèg	hàg	gùn

In words of less than three syllables, any tone can appear on any syllable, regardless of the foot structure or syllable weight. The following table shows examples of the possible combinations of tones in Kera disyllabic words with the same 7 melodies already seen on nouns.

(15) *Tone melodies on Kera disyllabic words*

	1 foot	more than 1 foot
L	(gèdèl) 'mud' (gǐsǐ:) 'mat'	(gɔ̀r)(nɔ̀y) 'hyena' (bɔ̀ɔ)bɛ̀ 'start of dry season'
M	(kēlēw) 'flute' (fīfīr) 'ceremonial drum'	(kēf)(tēr) 'book' (lāa)wē 'sadness'
H	(kókɔ́y) 'nuts' (kárám) 'women'	(cúŋ)(kúy) 'spear' (tɔ́ɔ)má 'snake'
LH	(gùɓú:) 'stand for pots' (mə̀sár) 'white foreigner'	(gɨ̌ɨ)(gúr) 'chickens' (màs)ká 'uncultivated land'
HL	(gégèl) 'basket/cage' (lógɔ̀m) 'humidity'	(lám)bà 'taxes' (máa)(hùr) 'flute'
MH	(sōlɔ́y) 'money' (mūrúy) 'horn (music)'	(kār)(mán) 'thing' (sēs)ká 'star'
HM	(kítīr) 'moon' (móŋɔ̄l) 'wall'	(kɔ́s)(lɔ̄m) 'laziness' (fár)tā 'skirt'

I conclude that for these words at least, the tone bearing unit seems to be the syllable. One foot can have two tones which are both realised:

(16) *Two tones in one foot, both realised*

(hùɗúm) 'hole'	(kítīr) 'moon'
| |	| |
L H	H M

Turning to trisyllabic words, there are restrictions on the combinations of tones. In these words, only one tone can be associated with each foot. The following examples show which

melodies are acceptable on which foot structures. Some of the examples include tone-bearing stray syllables, but the focus here is on the tone melodies within feet.[6]

(17) *Trisyllabic words with one tone per foot*

	(∪ –)– / (∪ –)(–)		(–)(∪ –)			
/LH/	(gə̀dàa)(yáw)	'pots'	(dàk)(tə́láw)	'bird'	*(gə̀táa)(yáw)	*(dàg)(də̀láw)
/HL/	(kə́sáa)bɔ̀	'locust'	(mán)(də̀hàŋ)	'sack'	*(kə́zàa)bɔ̀	*(mán)(tə́hàŋ)
/HM/	(kúɓúr)sī	'coal'	(sáa)(tərāw)	'cat'	*(kúɓūr)sī	*(sáa)(tə́rāw)

We know that the feet are iambic (∪ –) or (–). In the examples above, the tone patterns change at foot boundaries and are linked to syllable weight as all changes are after a heavy syllable. The example (gə̀dàa)(yáw) shows us that an analysis with left-to-right association of tones with syllables would not be adequate. We would have to claim a pattern of [LLH]. Then [LLH] would be allowable on (∪ –)(–), but not on (–)(∪ –), *(dàg)(də̀láw). Likewise (mán)(də̀hàŋ) shows us that a right-to-left association is not adequate either. As the weight/tone relationship holds throughout the lexicon, we are led to the conclusion that feet are associated with only one tone. The only exception to this is when the word has more tones than feet, as in (σ σ).

| |
T T

In words of three or more syllables, the foot is the TBU and tone is realised on the head. So as each foot has only one tone, the possible tone melodies on disyllabic feet in long words are /H/, /M/ and /L/. This tone associates with the head.

In disyllabic feet, it should be noted that the non-head may be realized as [M] if the preceding tone is not the same as the tone on the head. But this appears to be a case of undershoot rather than a phonological difference of tone between the head and non-head. Words with a H tone initial foot are realised as [MH...] in isolation, but [HH] if the previous word ends in a H tone. In (18), the thicker lines show the start and end of *kə́taasaw*.

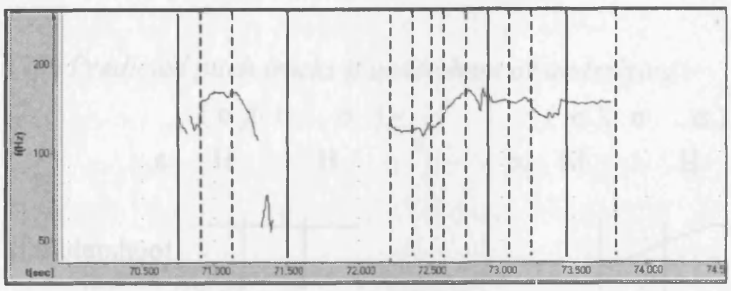
[6] The fact that this argument applies to words with stray syllables strengthens the case. We might expect the stray syllables to resist tones and for the foot to therefore carry two different tones, but the constraint on foot melodies is strong enough to force the stray syllable to be a tone bearing unit.

(18) *Undershoot in (H) disyllabic foot in isolation, but not with preceding H*

kə̄táasāw Hār lā bī mántɛ́ kə́táasāw pá

'cups' 'Return to ask for the cups again'

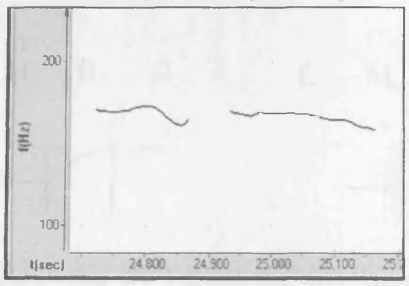
kə̄ táa sāw kə́táasāw



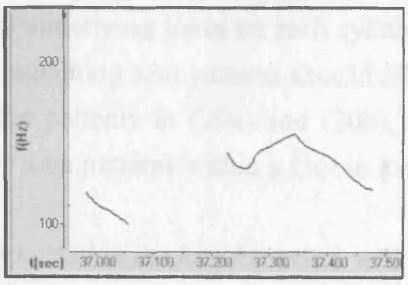
These two patterns of [MH] or [HH] also occur within a word depending on the tone of the preceding syllable.

(19) *Presence of undershoot depends on preceding tone*

(kúŋ)(kúrúŋ) > [(kúŋ)(kúrúŋ)] 'skin bag' [H-HH]



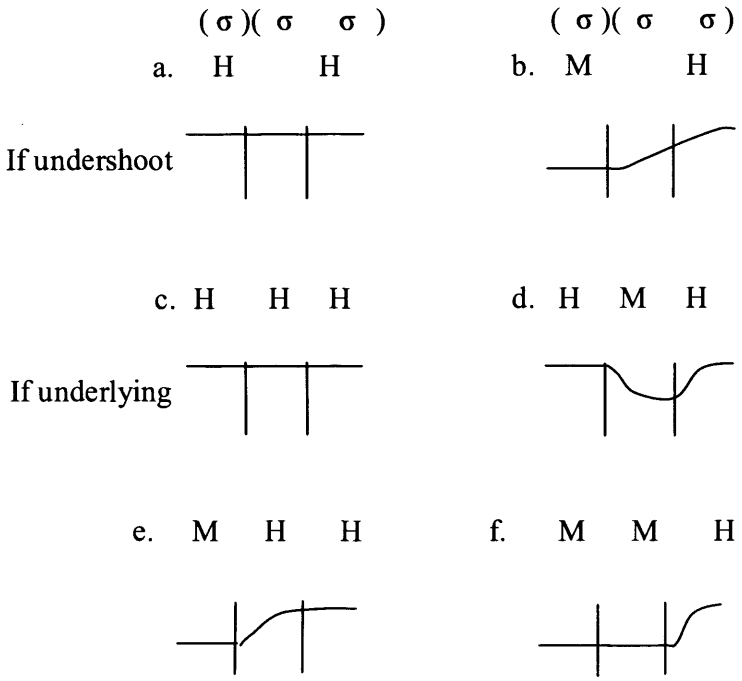
In contrast to: (dàk)(tə́láw) > [(dàk)(tə̄láw)] 'type of bird' [L-MH]



In the second example, there is an apparent falling F0 at the end of the final syllable for which I have no explanation, but the point to note is that the [tə] syllable does not achieve the H tone level. According to Prom-on et al. (forthcoming), there is no anticipation of the next tone, and movement only starts on the vowel which has the new tone as a target. According to them, it takes 150 ms to achieve the target tone in Mandarin. Xu and Sun (2000) have suggested a method of calculating the maximum speed of moving from one tone to another. According to their calculations, if the non-head vowel in the Kera foot has

a duration of less than 50 ms, then there is not enough time for the target to be reached. I would therefore expect to find undershoot if the preceding tone is not the same as the target. The following diagrams show the predictions for undershoot in contrast to underlying tones.

(20) *Predicted pitch tracks if undershoot or underlying*



If we have undershoot, we expect the disyllabic foot to have H tone after H as shown in (20a) and a rising M tone followed by H after M as shown in (20b). If on the other hand we are dealing with underlying tones on each syllable (which could be a default M tone or a H tone), then the remaining four patterns should all be possible on the disyllabic foot. In Kera, we find only the patterns in (20a) and (20b), so this leads us to suppose that we have undershoot. The tone patterns within a foot in longer words are therefore:

(21) *Tone patterns within the foot for words with more than one foot*

/H/	(σ σ)	/M/	(σ σ)	/L/	(σ σ)
[H H]	H	[M M]	M	[L L]	L
(or [M H] with undershoot)				(or [M L] with undershoot)	

In the discussion that follows, we will assume, ignoring undershoot, that all tones spread within the foot as shown above, from the head onto the non-head. The involvement of the

foot is crucial in the analysis of long words. The boundary between tones in a word has to coincide with a foot boundary and each foot is associated with only one tone. If the TBU was the syllable in these words, I would expect at least the seven melodies that are found in nouns within the foot, if not nine melodies. But as we only have three possible melodies, I conclude that we are dealing with the foot as the TBU. This is the only way of explaining the link between the possible tone patterns and syllable weight. The possible metrical patterns for trisyllabic words are: (∪ –)(–), (–)(∪ –) and (–)(–)(–). These words have the same underlying melodies as disyllabic words, giving us seven possibilities: L, H, M, LH, HL, MH, HM. The following table shows all the possible combinations of these. X marks combinations that are not possible if the TBU is a foot. For these combinations, no examples exist in Kera. Blank squares indicate combinations that could be possible according to this analysis, but for which I have found no examples.

(22) *Potential tone patterns and foot structure in trisyllabic words*

		(∪ –) –	(–)(∪ –)	(–)(–) – / (–)(–)(–)
/L/	LLL	(ɗɨ̀mɨ̀ɨ)mɨ̀ 'clothes'	(bɔ̀m)(bɔ̀rɔ̀ŋ) 'carp'	(jàm)(wàa)lɛ̀ 'victory song'
/H/	HHH	(kə́kám)ná [MHH] 'chiefs'	(kúŋ)(kúrúŋ) 'skin bag'	(máy)(fáa)tá 'dried carp'
/M/	MMM	(cēlɛ̄ɛ)rɛ̄ 'commerce'	(kāŋ)(kəlāŋ) 'hat'	(bāa)(sāy)mɔ̄ 'type of bird'
/LH/	LLH	(gə̀dàa)mɔ́ 'horse'	X	
	LHH	X	(dàk)(tə́láw) [LMH] 'type of bird'	(hàm)(pɔ́r)lɔ́ 'viper'
/HL/	HHL	(kə́sáa)bɔ̀ [MHL] 'cricket'	X	
	HLL	X	(mán)(dəhàŋ) 'bag'	(máa)(vɔ̀r)gɔ̀ 'ulcer'
/MH/	MMH	(ɨ́ɨ̄ŋ)kɨ́ 'hole'	X	(māy)(tɛ̄l)(fɔ́n) 'tape recorder'
	MHH	X	(tāa)(mə́ká:) [MMH] 'sheep'	(māy)(kɨ́f)rí 'type of tree'
/HM/	HHM	(kúɓúr)sī [MHM] 'burning coal'	X	(ɗɛ́w)(máa)tā 'vegetable'
	HMM	X	(sáa)(tərāw) 'cat'	(máy)(wāa)rɛ̄ 'newly wed'

The examples in the last column are probably all compounds or loan words. No other examples of this length are available. Kera has very few words containing three feet or more than four syllables, apart from compounds. Compounds and loans do not always follow the same rules for tone as monomorphemic words, but most of the examples here do fit the same pattern. *māytēlfɔ́n* and *dɛ́wmáatā:* imply that there can be three underlying tones, but these are compounds and therefore do not make a strong case for the existence of three tones in a word.

Concentrating on the words with two feet where the data contain no compounds, this table shows that all tone melodies that would be expected to occur do in fact occur. The table also shows that no tone patterns exist which would disprove the TBU being the foot. A small selection of the words from (22) are shown below with the tone associations:

(23) *Tone associations for a selection of nouns*

(dàk)(tə́láw)	'type of bird'	*(dàk)(tə̀láw)	
L H		L H	
(sáa)(tərāw)	'cat'	*(sáa)(tə́rāw)	
H M		H M	
(kúɓúr)(sī:)	'coal'	*(kúɓūr)(sī:)	
H M		H M	
(gə̀dàa)(mɔ́:)	'horse'	*(gə̀dáa)(mɔ́:)	
L H		L H	

In all of these examples, the tone spreads within the foot and the foot is limited to one tone. Within the foot, tones spread from the head onto the non-head. Tones also spread to the right until they reach another tone, or a foot containing a tone. So the last tone in a word will spread to the end of the word. This applies to all three tones and involves all syllables. Note that in (24), the M is underlying because if it was not there, the H would spread throughout the word.

(24) *Spreading of M and H*

(ácɛ́ŋ)(lɛ̄ɛ)(rɛ̄:) 'type of vegetable'

H M

(kɔ̄r)(lɪ́kɔ́r)(lɛ́:) 'type of tree'

M H

Alternatively we could claim that H and L are associated with a foot in the lexicon and do not spread beyond the foot. This would require repeated H and L tones in neighbouring feet, but it would mean that M could be treated as a default tone rather than underlying. If I use a unary version of the Halle and Stevens (1971) features of [Slack] and [Stiff] instead of L and H (see chapter 6), then this approach is necessary as M would be the absence of both features and therefore not specified. To take this approach, I must assume that L is free to spread, but the spreading of H is restricted to the foot in monomorphemic words. In polymorphemic words, H does spread to the right. For the rest of the thesis, this is the approach I will take.

4.4 Further spreading of tones between roots and suffixes

If we take the foot as the feature bearing unit, this has repercussions for the analysis of tone in Kera in general. In this section, I will verify that the model can give a coherent account for nouns and verbs and the affixes associated with them.

4.4.1 Nouns

As we saw in (2), nouns can have 7 tone melodies: H, M, L, HM, MH, HL, and LH. The same melodies are seen in nouns with suffixes. we will look first at nouns without suffixes and then at inalienable nouns with suffixes. Recall that, if there are two tones and only one (disyllabic) foot, both tones are realized. As the two features cannot be realized on the same syllable, this forces the domain of each tone to be the syllable.

(25) [H] (káa)(sáw) 'millet'

H H

[L] (gàl)(gàw) 'skins'

L

[HM] (pák)(lām) 'handcuffs'

H

[LH] (bàr)(káŋ) 'master'

L H

[MH]	(kāɗ)(káw)	'grass'	[HL]	(táa)(bùl)	'table'
	|			| |	
	H			H L	

[M] (pāa)(tāl) 'needle'

4.4.2 Inalienable Nouns

The inalienable nouns generally carry a possessive pronoun suffix. The suffixes fall into two groups according to the resulting tone patterns.

(26)

Group a. (1st and 3rd person)[7]: -i (3pl), -a (3sgf), -u (3sgm), -ṇ (1sg)

Group b. (2nd person): -m (2sgm), -i (2sgf), -ŋ (2pl)

In the analysis below, group a. is represented by -i and group b. with -m (Other suffixes in the same group have the same tone patterns).

a. -i suffix, 5 underlying tone patterns.

This suffix is toneless, and tones therefore come from the noun roots (Pearce 2005b). If a root has only 1 syllable, it cannot have a contour tone so the second tone in the case of /MH/ and /LH/ must be realized on the suffix. The second tone is therefore a floating H that is realised on the suffix syllable (but is associated with the root in the underlying form).

(27)	/H/	/ø/	/ø-H/	/L/	/L-H/
	/kusr- y/	/kɔsn- y/	/tiir -y/	/gaby-y/	/guud-y/
	H		H	L	L H
	(kús)(rúy)	(kīs)nī	(tīi)rí	(gɨ̌b)(yɨ̌y)	(gùu)(dúy)[8]
	'their body'	'...ears'	'...skin'	'...cheeks'	'...behinds'
	[H]	[M]	[MH]	[L]	[LH]
	(6)	(4)	(5)	(5)	(4)

[7] The 1pl inclusive and exclusive pronouns form separate words, so these are not included here.

[8] The presence of both -y and -i as the same 3 ps plural suffix is a slight mystery which is discussed in section 1.4.6. There seems to be some phonological patterning as to whether the + or – consonantal affix is chosen, but also some variation, even for the same speaker.

As already stated, there are typically seven melodies that appear on nouns, but for inalienable nouns, we do not find the expected melodies [HM] and [HL]. There are a limited number of inalienable nouns so the absence of [HM] and [HL] could be an accidental gap. On the other hand, the absence of [HM] means that H may be spreading right onto suffixes, and the absence of [HL] means that L never appears as a floating tone. Both of these are plausible explanations for the gaps. The noun roots can carry two tones in the UR, even if they only have one syllable. A similar pattern is seen in Mende nouns (Leben 1978, Yip 2002) and Siane nouns (James 1994, Yip 2002), where a monosyllabic noun root can have two tones. If the suffix forms a second syllable, then the tone spreads onto that syllable. But these languages are unlike Kera in allowing contours, so both tones can still be realised on the same syllable as a contour.

(28) *Mende noun*

/mbuHL/	mbu-ma →	mbúmà	'owl-on'
	mbu →	mbû	'owl'

We cannot tell in Kera whether contours would be allowed in similar examples because the inalienable nouns never occur without some form of suffix and therefore have two syllables. The only monosyllabic form of these words that we find is their counterpart as prepositions. In this case, the preposition carries only one tone, but this doesn't tell us much as this tone matches the tones for the -m suffix (described below) in which there are never two tones anyway.

(29) *Kera inalienable nouns / prepositions*

gùudṇ́	'my behind'	gùudùm	'your behind'	gùd	'behind'
ɗɨrṇ́	'my eyes'	ɗɨrɨ̀m	'your eyes'	ɗɨr	'in'
káasṇ́	'my hands'	kāasām	'your hands'	kās	'by'

The majority of inalienable nouns have the foot structure (CVC)C- or (CVV)C-. The few inalienable nouns that do not fit this pattern can be classified as follows:

(30)

a. CVC-	/bar-LH/ bàrṇ́	'my father'
	/dɨr-LH/ ɗɨrṇ́	'my eyes'
	/mar-MH/ mārṇ́	'my wife'
b. (CVCVX)C-	/gɨgɨɨr-LL/ gɨ̀gɨ̀ɨrṇ̀	'my knee'
	/kɨsɨlɗ-MH/ kɨ̄sɨ̄lɗɨ̄n	'my tongue'

c. (CVC)(CVC)-	/kampar-MH/ kāmpárṇ	'my feet'
	/tarmay-MM/ tārmə́yán	'my heart'
	/kɔrmɔy-MM/ kɔ̄rmōyɔ̄n	'my son'

These words may have unusual foot structures, but the tone patterns still match the examples in (20).[9]

b. -m suffix, the tone patterns are reduced to two. The whole noun always has the same tone of M or L. So we can assume that any H is delinked and the default tone is M.

(31)	/H/	/ø/	/ø-H/	/L/	/L-H/
	/kusr-m/	/kɔsn-m/	/tiir-m/	/gaby-m/	/guud-m/
	H		H	L	L H
	kūsrūm	kūsnīm	tiirīm	gàbyàm	gùudùm
				L	L
	'your body'	'...ears'	'...skin'	'...cheeks'	'...stomach'
	[M]	[M]	[M]	[L]	[L]

The -m suffix (and other similar suffixes) carry a 'H delink' effect. This may have a grammatical rather than phonological motivation as it basically affects first and second person suffixes. This delinking is reminiscent of de-accentuation in Japanese and Russian as described by Alderete (1999a). In Japanese, a dominant affix can cause the accent on the root to be removed, even when the affix is not accented itself. So for the suffix –kko 'native of', both accented and unaccented roots surface as unaccented: /kóobe-kko/>koobe-kko 'native of Kobe' and /edo-kko/>edo-kko 'native of Tokyo'.

4.4.3 Verb suffixes

Verbs act in a similar way to inalienable noun suffixes (with no MH category).[10] The verb melodies when no suffix tone is involved are: /H/, /M/ and /L/ and /LH/. The structure of verb URs can be CVC, CVV, CVVC or CVCC-.

---

[9] See chapter 1, §1.4.3 for further discussion on the syllabic nasal suffix.

[10] It seems likely that the M tone verbs are loans as there are very few and they undergo no tonal changes. If so, verbs originally had no M tone form and the absence of MH is no surprise.

a. With **-i**, there are four tone melodies, and no changes take place to the tones. All L verbs with a sonorant (non-cluster) C_2 have a L melody. All L verbs of the form CVCCV, have a LH melody. All L verbs with an obstruent C_2, have a LH melody too.

(32)

fɨ̃lɨ̃y	kɨ̃yɨ̃y	jɩ̃irɩ̃	jɩ̃ɓrɩ̃
H		L	L H
find them	*help them*	*write to them*	*listen to them*
[HH]	[MM]	[LL]	[LH]

b. With **-m**, the tone melodies are reduced to just two as H is delinked in the same way as it is for the inalienable nouns.[11]

(33)

fə̃lām	kə̃yām	jèɛrèm	jèɓrèm
		L	L
find you	*help you*	*write to you*	*listen to you*
[MM]	[MM]	[LL]	[LL]

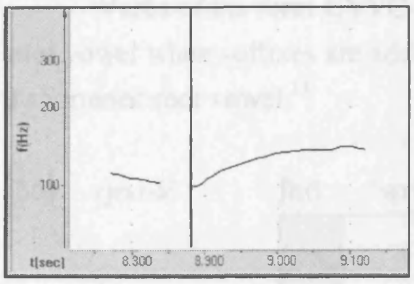
The tone patterns in (32) and (33) are very similar to inalienable nouns, except that in verbs foot structure appears to play a role in the choice of underlying melody. Also, verbs can receive multiple suffixes. The verbs with the tone melodies [H] [M] and [L], have only one tone in the root, so the foot structure makes no difference. But for verbs with [LH] in the root, the foot structure can affect the spread of tone. Taking each possible LH verb structure in turn, we can have the following forms:

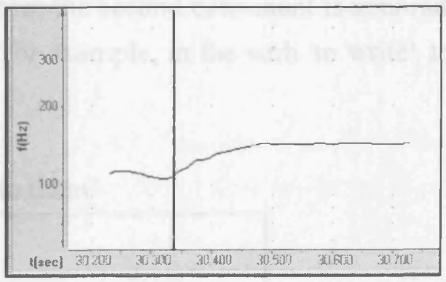
[11] In verbs, unlike nouns, the 1sg –n suffix is grouped with the –m suffix and it is not syllabic. All other suffixes appear similar in nouns and verbs. The 3sg indirect object suffixes have the same form as the direct object but with the tone patterns of the -m group.

(34)

a. /CVC- LH/

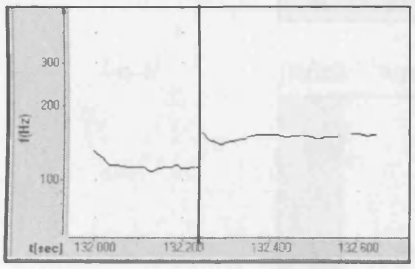
/dig-u/ (dìgú:) 'stop him' /dig-n-u/ (dìg)(nú:) 'stopped him'

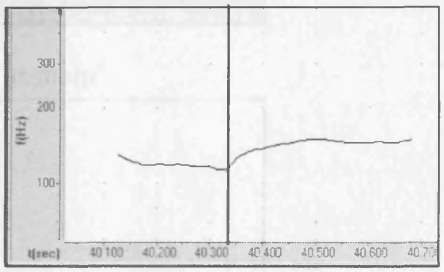




b. /CVVC- LH/

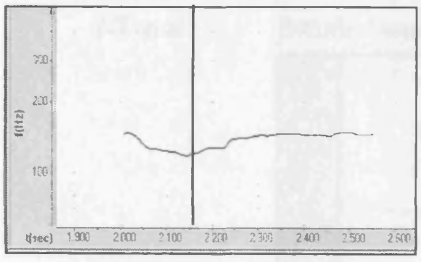
/baad-u/ (bɨ̈ɨ)(dú:) 'wash him' /baad-n-u/ (bɨ̈ɨ)(dúnú:) 'washed him'

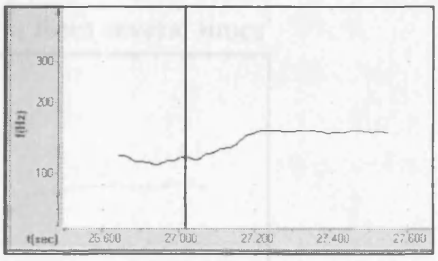




c. /CVCC- LH/

/jɛɓr-ɛ/ (jɛ̀ɓ)(ré:) 'listen to him' /jɛɓr-n-u/ (jìɓ)(rúnú:) 'listened to him'





d. /CVV- LH/ - (To my knowledge, no CVV verbs with LH exist)

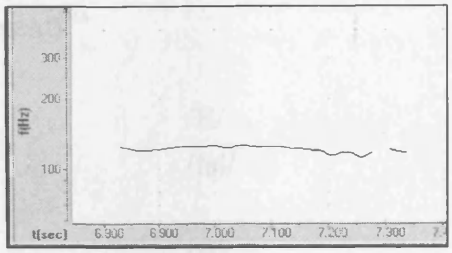
These patterns are all consistent with the principles outlined in §4.3.3, so in two syllable words both tones are realised, but in three syllable words, the first foot takes the first tone and the second foot takes the second tone.[12] (In words with two syllables, the line indicates

[12] We cannot prove that these patterns originate from the foot structure because all verbs with multiple suffixes have a heavy first syllable, and the change to the second tone is therefore always on the second syllable. But by analogy with nouns, the foot analysis fits the facts and avoids positing different systems for different parts of speech.

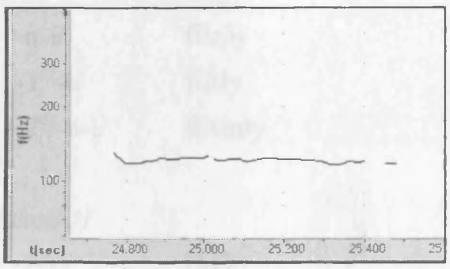
the syllable boundary, and in words with three syllables, the foot boundary is marked by the line.) Note that there are no examples with two tones where the first tone extends further than the first foot, so *(jìɓ)(rùnú:) would be impossible.

Verbs of the form CVVC- where the second consonant is sonorant often shorten the root vowel when suffixes are added, for example, in the verb 'to write', the form *ɟìrtínî:* has a shortened root vowel.[13]

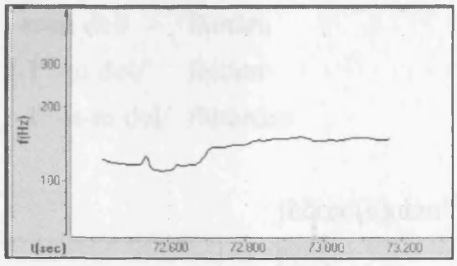
(35) /jɛɛr-i/ ɟìirǐ: 'write to them'



/-n-i/ ɟìirǐnǐ: 'wrote to them'



/-T-n-i/ ɟìrtínî: 'wrote to them several times'



However, this still leaves a heavy first syllable so the same tone placement rules apply. There are no cases where a shortening process produces a light syllable which then links to the next syllable to form a foot.

[13] Unfortunately, there are no verbs with multiple suffixes which have a light first syllable, so we cannot prove that the division between tones coincides with a foot boundary. According to the verb data, we would assume the TBU was the syllable, but with the noun data, the simplest account is to say that the TBU is the foot regardless of the grammatical category.

4.4.4. Effects of the suffixes -n and -T.

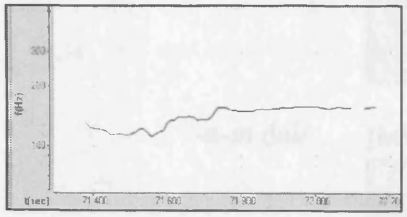
-n is the perfective suffix which has no effect on tone and -T is the habitual suffix which is realised as [t] or [d] depending on the F0 height of the following syllable, and which carries a H tone (written as -T^{H} below). The H tone of –T can be deleted by the suffixes which delink H. In this case, the VOT of –T shortens and it is perceived as [-d]. Note this effect in the following examples.

For /H/, /M/ and /LH/ tone verbs, the presence of –T has no effect on the tone. Note that the suffix –n carries no tone, and –m has the effect of delinking any H tones (after which L spreads if present).[14]

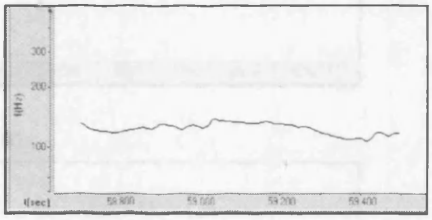
(36)

		/H/	/LH/
		/fal/	/jɛɓr/
no change			
		[H]	[LH]
3pl	/-i /	fìlɨ́y	jìɓrî:
perf 3pl	/-n-i/	fìlnɨ̀y	jìɓrînî:
hab 3pl	/-T^{H}-i/	fìltɨ́y	jìɓrîtî:
hab perf 3pl	/-T^{H}-n-i/	fìltɨ́nɨ̀y	jìɓrîtînî:
-m causes delinked H			
		[M]	[L]
2m	/-m del/	fə̄lām	jɛ̀ɓrɛ̀m
perf 2m	/-n-m del/	fā̀lnām	jɛ̀ɓrɛ̀nɛ̀m
hab 2m	/-T^{H}-m del/	fā̀ltām	jɛ̀ɓrɛ̀dɛ̀m
hab perf 2m	/-T^{H}-n-m del/	fā̀ltə̄nām	jɛ̀ɓrɛ̀dɛ̀nɛ̀m

jìɓrît(î)nî:



jɛ̀ɓrɛ̀d(ɛ̀)nɛ̀m[15]



[14] From this point on, we will omit the M verbs as there are very few of them, they seem to be loans and they do not change tones as other verbs do.

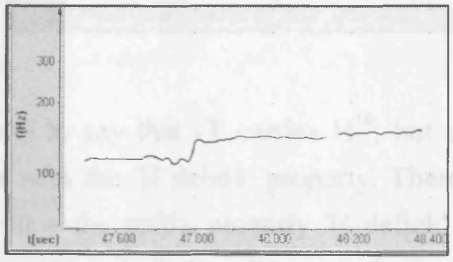
[15] This particular speaker omits the segment in parentheses. The footing of long words such as these is discussed in chapter 2, §2.2.10.

However, for L verbs, with an -i suffix, the -T is followed by H tone. Firstly with the –i (3pl.) suffix, all is as expected:

(37)			[L] (as expected)	
a.	/jɛɛr-i/	/-i/	ɲ̃iirǐ (see (35))	'write to them'
		/-n-i/	ɲ̃iirǐnǐ (see (35))	'wrote to them'

But when T is added, we find a H tone. In the /L/ tone examples in (36) the H tone was obscured by the underlying L, but now we see evidence for the H being on -T

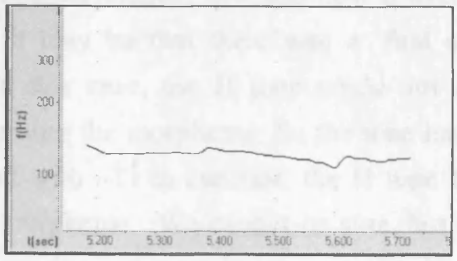
		[LH] (-T with H tone)	
b.	/-T^{H}-i/	<u>ɲ̃irtí</u>	'write to them repeatedly'



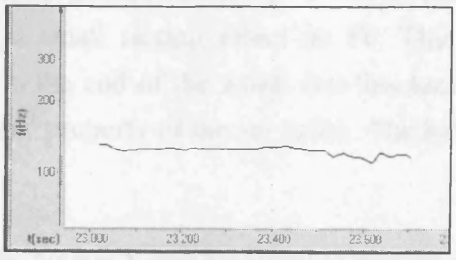
	/-T^{H}-n-i/	<u>ɲ̃irtínî</u> (see (35))	'wrote to them repeatedly'

For the suffix –m which delinks H, there is no H tone even if –T is present

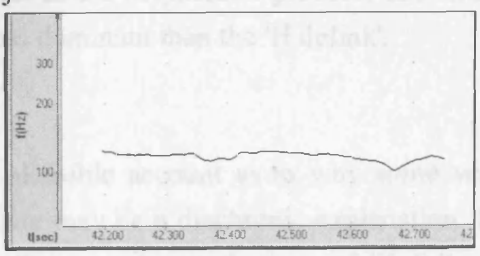
		[L]
c.	/-m del/	jɛ̀ɛrɛ̀m



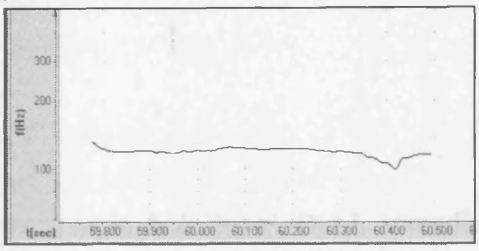
	/-n-m del/	jɛ̀ɛrɛ̀nɛ̀m



/-T^{H}-m del/ jèrdèm



/-T^{H}-n-m del/ jèrdènèm



The easiest way to account for this is to say that -T carries H[16], but that this H is still delinked if the word carries a suffix with the 'H delink' property. There is no diachronic tonogenesis account available as to how the suffix property 'H delink' developed. But a similar property is found in other languages including Xhosa and other Bantu languages (Downing 2003 and Kenstowicz 1993), so it is not without precedent. The suffixes that carry this property do not fit neatly into a set of sonorants, vowels or obstruents. So a typical tonogenesis account is not possible to cover the 'H-delink' facts. In fact a suffix with the phonetic form [-i] appears in both groups with contrastive meaning. So we are left with a question as to how the 'H-delink' developed, and also how it overrides the H tones from both roots and other suffixes. It may be that there was a 'first or second person' morpheme marked only by tone. In this case, the H tone could not dislodge the tone without losing the information concerning the morpheme. So the tone had to be realized at the expense of the H tone associated with –T. In contrast, the H tone from –T could be dropped while still realizing the –T morpheme. We cannot be sure, but this is a plausible account.

The effect of T can be explained diachronically. If -T was at one time a voiceless obstruent *–t*, it would have caused a small raising effect on F0. This could then have developed into a tone which spread to the end of the word. But this tone did not have the strength to dominate over the 'H delink' property of the -m suffix. The habitual –T is rarely

[16] This gives us a problem for the [M] verbs, because T does not appear to raise the tone in these verbs. I suggest that these (very rare) verbs are loans which were never subject to the same constraints.

used in natural speech and comes late in the acquisition process, and this could suggest another reason for the H tone being less dominant than the 'H delink'.

4.4.5 Diachronic account for verbs

Synchronically, it is hard to give a plausible account as to why some verbs have a LH pattern and others a L pattern. But there may be a diachronic explanation. In this account, verbs were originally toneless. Then the natural perturbations of F0 following obstruents led to a split into tone patterns:

(38) CVCV → C voiced L.....
→ others H.....

In general, L spread throughout the word as in *bèlè* 'love'. But L spreading was blocked by two contiguous consonants and by voiceless obstruents.[17] This produced a LH pattern.

(39) C_1VC_2V → C_1 voiced L..... → a) C_2 sonorant /L/
→ b) C_2 voiceless /LH/
→ c) CVCCV /LH/
→ others H..... /H/

If there were any verbs with two voiced obstruents, these may have merged with the /LH/ verbs with a voiceless second consonant when the voicing distinction began to disappear. Several languages lose a voicing distinction in final consonants first (Blevins 2006) so this is not an unreasonable assumption.

In the next section, we consider an optimality theoretic approach which can adequately account for the interaction between tones and feet and the difference in tonal specification depending on the number of feet in the word.

4.5 OT analysis of tone spreading

I have established that the syllable seems to be the TBU for short words and the foot is the TBU for long words. This is explained by the following facts:

[17] The reason for the CC cluster blocking tone is unclear, but it could be related to foot structure. A similar pattern occurs in Lagwan (Ruff 2005, p.c.) and other Chadic languages.

(40)
(i). The foot is preferred as TBU.
(ii). Contour tones are not allowed, but all tones must be realised.
(iii). Possibly without exception, Kera monomorphemic words have a maximum of two underlying tones, so any word with two feet can realise all the tones on heads.
(iv). However, in words containing only one foot, the non-heads may need to carry a separate tone in order for all the tones to be realised.
(v). L tones spread to the right. H tones spread to the right in polymorphemic words. In monomorphemic words, H does not spread beyond the foot.

For this account, I will assume that a constraint which ensures that Kera has no tones on consonants is high ranked.[18] We need a constraint which defines the foot as TBU and a constraint that makes sure that tones are realized.

(41) NoContour Ft: The foot is only associated to one tone.
Realise T: Tones must all be realised.

I have also said that there are no contour tones. The constraint NoContour σ is therefore undominated, and so is Specify:

(42) NoContour σ: No contour tones.
Specify: All syllables should be associated with a tone.

The grammar we need to describe Kera is:

(43) *Kera tone/foot interaction grammar*
NoContour σ, Specify » Realise T » NoContour Ft

Consider first the word /kəsaabɔ:/
HL

[18] The syllabic nasal is an exception as it may carry a different tone from the rest of the word.

(44) *Tones on heads of feet in three syllable word*

kəsaabɔ: 'cricket' H L	SPECIFY	NoCONTOUR FT
☞ a. (kə́sáa)(bɔ̀:) H L		
b. (kə́sàa)(bɔ̀:) H L		*!
c. (kə̄sáa)(bɔ̀:) H L	*!	
d. (kə́sāa)(bɔ̀:) H L	*!	
e. (kə́sàa)(bɔ̄:) H L	*!	*!

In tableau (44) the candidate (44e) violates both constraints and is therefore excluded. (44c) and (44d) violate the constraint SPECIFY by having no tone on one of the syllables. Candidate (44b) is ruled out because the two tones within the foot do not agree. The ranking of the two constraints is not yet established.

Now turning to a one-foot two-syllable word with the same tonal melody, we see the role played by the constraint REALISE T so that each syllable is associated to a tone in the winning candidate. This constraint must be ranked above NoCONTOUR FT to rule out the second and third candidates. The fourth candidate is ruled out by SPECIFY. At this point the ranking of NoCONTOUR σ is unclear.

(45) *Tones on each syllable in two syllable word*

kəbaŋ 'tree' H L	NoContour σ	Specify	Realise T	NoContour Ft
☞ (kə́bàŋ) | | H L				*
(kə́báŋ) \ H			*!	
(kə̄báŋ) | H		*!	*!	
(kə̄bâŋ) \ H L	*!	*!		*

To motivate the ranking NoContour σ » Realise T, we look at a monosyllabic word with two underlying tones. In the following example, the word /bɛgɛ/ is disyllabic underlyingly, and is pronounced with two vowels in phrase-final position. But in phrase medial position, the final vowel is deleted, making the word monosyllabic with two underlying tones. This is the form which is given in the tableau below for simplicity. The winning candidate deletes the second tone rather than keeping a contour.

(46) *No contours on a syllable – a monosyllabic word*

bɛg 'animal' L H (phrase medial)	NoContour σ	Specify	Realise T	NoContour Ft
☞ (bɛ̀g) | L			*	
(bɛ̌g) \ L H	*!			*

To complete the grammar, I further motivate the use of NoContour Ft. The need for this constraint is seen in a three syllable word of the form (σσ)(σ). In (47), candidate (b) demonstrates that no contours in the foot are allowed while candidates (c) and (d) also motivate the constraint Specify, which is needed so that the L tone spreads to the left.

(47) *No contours within a foot in a three syllable word*

dɨbɨŋga 'cold' LH	NoContour σ	Specify	Realise T	NoContour Ft
☞ a. (dɨ̀bɨ̀ŋ)(gá:) L H				
b. (dɨ̀bɨ̂ŋ)(gá:) L H				*!
c. (dɨ̀bɨ̀ŋ)(gá:) L H		*!		
d. (dɨ̀bɨ̄ŋ)(gá:) L H		*!		

This gives us the final grammar:

(48) NoContour σ, Specify » Realise T » NoContour Ft

This grammar describes the key Kera facts. Heads carry tones, no contour tones are allowed and all tones are realised. The foot is preferred as the TBU, but the syllable becomes the TBU if there are not enough head syllables for all of the tones to be realised on the heads. Tones spread within feet, and beyond, if no other tone is specified.

I have now established the ranking, but we should verify that this grammar also applies to the other possible combinations of tones and feet. The next two tableaux show the other combinations of feet with two tones:

(49) *2 tones on disyllabic foot*

məsar 'foreigner' LH	NoContour σ	Specify	Realise T	NoContour Ft
☞ a. (məsár) L H				
b. (məsàr) L			*!	
c. (məsar) L H	*!	*!		

(50) *2 tones on trisyllabic foot, first syllable heavy*

daktəlaw 'bird' LH	NoContour σ	Specify	Realise T	NoContour Ft
☞ a. (dàk)(tə́láw) | / L H				
b. (dàk)(dəláw) / | L H				*!
c. (dàk)(tə́lāw) | | L H		*!		

This covers all cases where the underlying form has two tones.[19] If the underlying form has only one tone, the grammar also works. These cases are trivial because Specify makes sure that the tone spreads to all tones and Realise T makes sure the tone is the tone in the underlying form. In all of these tableaux, I assume that Dep T is highly ranked, so the winning candidate will always be the one where the tone spreads throughout the word.

4.6 Discussion of the tone bearing unit

We have seen that Kera exhibits the following interaction between the metrical system and tone:

(51) *Tonal and metrical interaction in Kera*

a. Tones are associated to heads.

b. Non-heads and heads within the same foot cannot be associated to different tones except in words of two syllables.

c. Tone spreads within the foot and beyond if no other tone is specified.

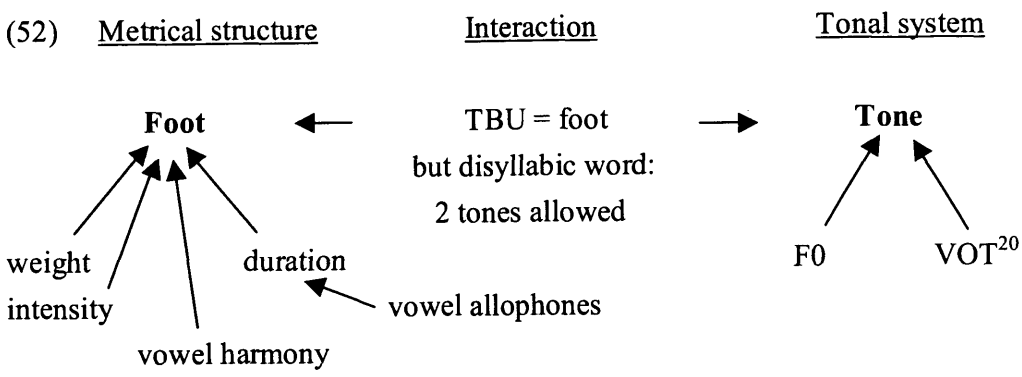
d. The placement of tone is partially dependent on the metrical structure. Tone does not dictate the foot shape.

e. The number of tones that can be associated with a root appears to be limited to two. This may be accidental as most words are too short to have more than two tones, or it could be evidence for a restriction at word level for monomorphemic words.

[19] We have not discussed M tone words here. If /M/ is an underlying tone, then the same constraints will deal with /M/ too. If M is a default tone and not underlying, we would need a constraint ranked above Specify which stops H spreading beyond the foot in monomorphemic words.

In summary, the Kera interaction is as follows:

(52)

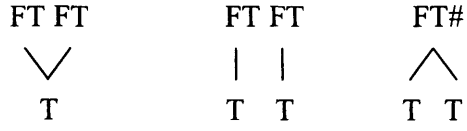


The arrows in this diagram show the cues that indicate the shape of the foot or the tone height. The weight is the main indication for the position of the foot, with intensity and duration as supporting cues. The vowel allophones give support to the duration. The tonal and vowel harmony systems mark the boundary of the foot by the limits of certain spreading domains. The F0 value is a stronger cue for the tone than the VOT in most Kera dialects, but the VOT still has a role to play in enhancing the perception of tone.

The interaction between tone and foot comes from the use of the foot as a TBU in words which have enough syllables for all the tones to be realised.

There are three possible situations with regard to the number of feet and the number of tones. If there are more feet than tones, the tone will spread. If there are the same number of feet as tones, there will be no spreading. If the number of tones is more than the number of feet, the two tones will both be realised on one foot.

(53) *Combining tones at foot level, with TBU = foot*



If two tones are realized on one foot, we might assume that the syllable is the TBU. However, analytically this is not necessarily the case. It may be that one tone appears on each syllable because there is a restriction on contours within a syllable, or it could be quite simply that there is not enough time for the two tones to be pronounced on the first syllable so it will appear that each syllable has one tone. In any case, the simplest analysis for Kera

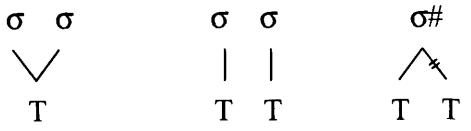
[20] Some of these cues carry more weight than others. The importance of each cue depends on the dialect, as described in chapter 5.

is to say that the TBU is the foot, but that the foot can have two tones if this avoids tone deletion. In later chapters, I will assume that the foot is the TBU, but that contour tones on syllables are not permitted. Two tones are allowed in disyllabic feet if this avoids the need to delete a tone.

In languages that do have the syllable as TBU, the same sort of patterns can take place at syllable level. Contour tones can be avoided by deleting one of the tones. This is a possible way to analyze Kera, but it is simpler to say that the TBU is a foot with a maximum of two tones.

(54) *Combining tones at syllable level if TBU = syllable*

At syllable level:



In this thesis, we have seen that Kera differs from typical syllable-tone languages such as Cantonese (Duanmu 1994), but that it also differs from typical word-tone systems such as Margi (Williams 1976) and Lithuanian (Blevins 1993). Kera represents a third type, a foot-tone language. Duanmu (1994) claims that the tonal domain for Shanghai is also a foot. Kera and Shanghai are similar in that the heads of feet appear to be associated with tones.[21] But there is an important difference. In this analysis of Kera, tones can *migrate* to foot heads. In Shanghai, each syllable has its own underlying tone, and there is no migration; instead, tones are only *retained* on foot heads. This means that even within the category of 'foot-tone language', there are still important differences in the details of the interaction between tone and foot structure. This is certainly an area of typology that merits further investigation.

In the previous section we arrived at a grammar which gives us one tone per foot in three syllable words and up to two tones on the foot in two syllable words. The foot is the TBU, but we do not need to use any TBU constraints. The constraint NoContour Ft is doing the same work that TBU = Ft would do. In fact TBU= Ft implies simply that there is only one tone per foot. This could be covered by NoContour Ft or Agree T Ft, depending on whether there is spreading throughout the foot. For Kera, we could have used either NoContour Ft or Agree T Ft because if used in conjunction with Specify, we get the same results. These constraints could replace the TBU constraint.

[21] There is however an alternative analysis presented in chapter 6 where the tones align with boundaries rather than the head of the foot. If this analysis is correct, Kera is not very similar to Shanghai.

(55) *Alternative constraints for TBUs (Pearce 2006a)*

	No spreading	*Spreading*	*Result*
TBU μ	-	-	One tone per mora (unless there are more tones than moras)
TBU σ	NOCONTOUR σ	AGREE T σ	One tone per syllable (unless there are more tones than syllables)[22]
TBU FT	NOCONTOUR FT	AGREE T FT	One tone per foot (unless there are more tones than feet)
Word tone	NOCONTOUR ω	AGREE T ω	One tone per word (unless there are more tones than words)

4.7 Conclusion

In this chapter, we have established that Kera (using the standard Kera dialect) has three contrasting tones. The contrast is enhanced by a link between voicing and tone, but that the contrast remains when there are no voicing cues. This relationship will be examined further in the next chapter. We have identified a link between foot structure and tone. In mono- and di-syllabic words, this relationship is obscured by the fact that tones must be realized, but in words with three or more syllables, the foot is clearly the tone bearing unit. We have established a grammar for these facts within an Optimality Theory framework. Through this, we have seen that AGREE and NO CONTOUR constraints can apply at multiple levels within the phonological hierarchy.

Kera illustrates that, even without overt stress at the word level, languages exist which have an interaction between the foot and a number of other phenomena including tone. Although it should be possible for the tonal and metrical systems to be totally independent, Kera shows how a tonal system can be sensitive to metrical structure. In Kera, this relationship is partially hidden because it only surfaces when the faithfulness condition of REALISE T is satisfied. Nevertheless, Kera adds to the list of languages that show that in tonal languages as well as in stress accent languages we can find a robust metrical structure which interacts with the tonal system.

[22] If there are more tones than syllables, the extra tones may appear at an edge or be deleted. The same is true for the other phonological categories.

Chapter 5

Tone and voicing interaction: Experimental evidence

5.1 Introduction

In the previous chapter, we considered the interaction of tone with the metrical structure of Kera. We saw that the two systems are partly independent, but that tones spread within the foot providing this does not leave an underlying tone unrealised. We now move on to the relationship between tone and voicing. We will see that the amount of use of VOT depends on the amount of contact with French and also the gender of the speaker. Interestingly, in the village location, the women speak a dialect that is more conservative, with special attention to the tonal contrast. However, in the town, women are more ready than their male counterparts to take on changes, moving towards a voicing contrast with little tonal contrast.

We will begin this chapter, in §5.2, by considering the relationship between tone and voicing that exists in the world's languages with special emphasis on claims that have been made for Chadic languages. Within this section, we will consider the ways that tones can develop, looking first at the world's languages and then focusing in on Chadic (§5.3) and finally Kera (§5.4). The earlier part of the chapter is of necessity more subjective, but the main focus of the chapter from §5.5 onwards will be on the synchronic changes in the tone and voicing relationship, and for this section, we will use empirical measurements. With the help of a perception experiment (§5.5) and detailed phonetic measurements of production (§5.6), we will look at a comparison of English, French and Kera, and the claims outlined above for Kera dialects. In §5.7, we will discuss some of the socio- and psycho-linguistic issues raised by these results such as the role of gender in dialectical differences and the question as to whether some Kera speakers are changing their grammar as adults. We will also examine the issue as to whether a 'critical age' exists for learning a new grammar.

5.2 Voicing and Tonogenesis

We will start with a brief investigation of the kinds of VOT contrasts that exist in the world's languages and then move on to a survey of cases where tonogenesis appears to have taken place. The discussion will include references to other more detailed surveys on this topic such as the comprehensive study by Bradshaw (1999). As well as the main themes concerning the effects of voicing on tone and the concept of depressor consonants, we will also consider the effects of sonorants on tonogenesis, and the loss of voicing that often accompanies an increase in tone.

5.2.1 VOT contrasts

Kera speakers do not have any truly voiced obstruents. It is probable that they did in the past, but synchronically, all VOT measurements are positive. There are differences in the use of VOT between Kera living in town or in a village, but for all of them the overall VOT values range from 0-70 ms. For Village Women, VOT is not contrastive. This means that for all stops they are free to use any VOT value within the range. In the table and graph below, Kera (the village dialect) can be compared with other languages which have a very different pattern, taking the figures from Ladefoged (2001) and Ohala (1995). English has a contrast between aspirated and non-aspirated voiceless obstruents. Spanish has a voicing contrast and Thai has a three way contrast. This is to be compared with the Kera archiphoneme VOTs of K: 10-70 ms, T: 5-60 ms, and P: 0-50 ms.

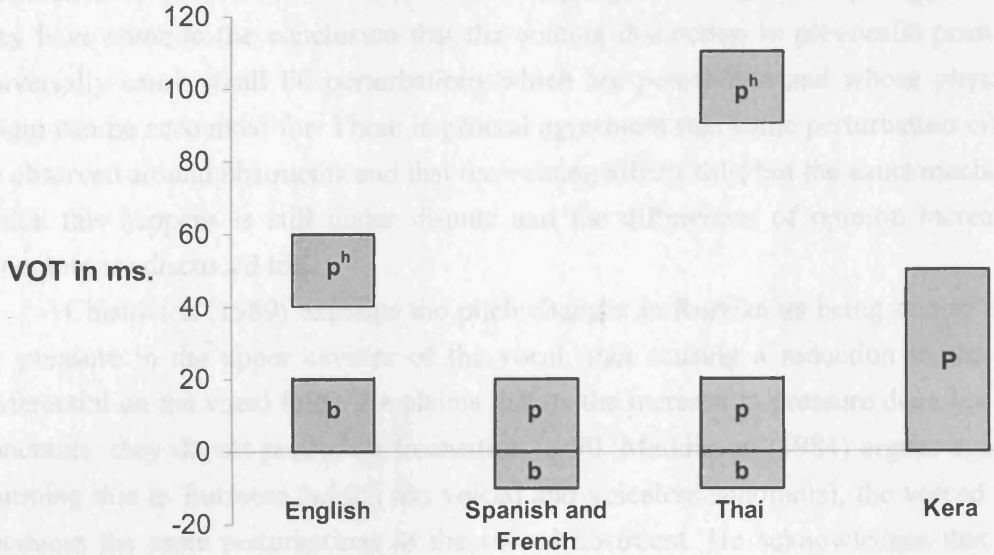
(1) *Comparison of VOT contrasts between English, Spanish and Thai*

English VOTs: *(and Germanic)*	k^h t^h, p^h	50-70 ms 40-60 ms	aspirated
	g, b, d	0-20 ms	unaspirated
Spanish VOTs: *(and Romance)*	k p, t	20 ms 0-20 ms	unaspirated
	g, b, d	negative	prevoiced
Thai VOTs	p^h	100 ms	aspirated
	p	0-20 ms	unaspirated
	b	negative	prevoiced

(Ladefoged 2001, Ohala 1995)

In the graph below, these facts are laid out in graphic form for easy comparison. Note that Kera has no contrast, so there is no dividing line marked on the range from 0-50 ms.

(2) *Comparison of VOTs for p/b consonants*



Because the Kera and English ranges are similar, these two languages are compared in the production measurements section of this chapter. We will see there that although the range is similar, the use of VOT is very different between these two languages. We can speculate that Kera originally had a voicing contrast rather like that of Spanish or French, but that as tones developed, voicing was lost. We will discuss the processes of tonal development and voicing loss in the next section.

5.2.2 Tonogenesis

Lisker and Abramson (1964) and Hombert et al (1979) have shown that in several languages, voiceless obstruents are pronounced with slightly higher F0 than voiced obstruents. For the tonogenesis account to be plausible, these perturbations in F0 following voiced and voiceless obstruents must be universal phonetic effects, and also there must be some reason why a number of languages have exaggerated this difference to produce contrasting tones. We will look first at the basis for phonetic perturbations in F0.

Ohala (1973) claims that a variation in pitch takes place through changes in the vocal fold tension. This comes about through several factors: a.) stiff/slack vocal folds when producing voiceless/voiced obstruents respectively (Halle and Stevens 1971), b.) a raised larynx for the voiceless obstruent and lowered larynx for the voiced obstruent. c.) lessening of the tension of the vocal folds when producing breathy voiced stops. d.) the larynx being pulled by the tongue when producing high vowels, giving a higher pitch. These types of pitch perturbations are typically small but in languages such as English and

Russian, the pitch changes do provide perceptual cues for identifying voiced stops. Hombert et al (1979) have studied several languages looking at the perceptual cues and they have come to the conclusion that the voicing distinction in prevocalic position does universally cause small F0 perturbations which are perceptible and whose physiological origin can be accounted for. There is general agreement that some perturbation effects can be observed around obstruents and that the voicing affects this, but the exact mechanism by which this happens is still under dispute and the differences of opinion increase when sonorants are discussed too.

Chistovich (1969) explains the pitch changes in Russian as being due to increased air pressure in the upper cavities of the vocal tract causing a reduction in the pressure differential on the vocal folds. He claims that as the increase in pressure does not arise for sonorants, they do not produce a fluctuation in F0. Maddieson (1984) argues against this, claiming that in Burmese (which has voiced and voiceless sonorants), the voiced sonorant produces the same perturbations as the voiced obstruent. He acknowledges that in some Chadic languages such as Podoko (Anderson and Swackhamer 1981), Lame and Kera (Ebert 1977), sonorants have a different effect on the pitch track than voiced obstruents, but he still claims that the predominant pattern is that sonorants act like voiced obstruents. He therefore concludes that the explanations such as those of Chistovich which look only at obstruents are not adequate. Lowes (2006) has yet another view on sonorants. Rather than saying that they follow behind the voiced obstruents in lowering the F0 value, she claims that they are the driving force through which tone entered the language in the cases of Lhasa Tibetan, Tshangla and Kurtoep. Her reasons for this claim include the fact that tonogenesis appears to be happening now in Kurtoep with the voiced stops becoming voiceless, but the tone following sonorants has already been established.

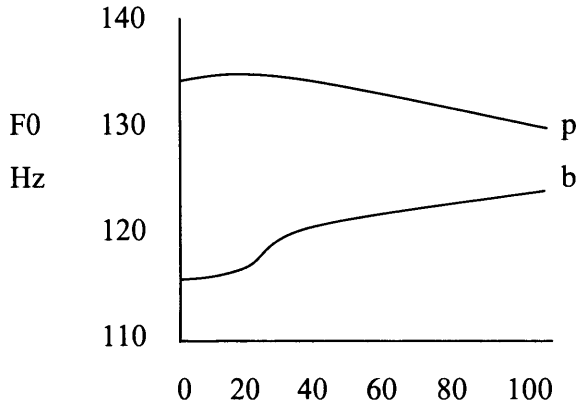
If we accept that the F0 perturbations do take place, we must still account for how these developed into the sort of differences that can maintain a contrast. Hyman (1973) and Hombert et al (1979) have claimed that once languages are using slight pitch changes as perceptual cues for voicing, it is a small step for listeners to consider the pitch change to be the major acoustic cue to differentiate words which are also differentiated by voicing or VOT. As the listener is not aware of the actual grammar in the mind of the speaker, certain cues can be exaggerated if they are perceived as being pertinent.[1] The language then becomes tonal as the pitch differences are produced intentionally and used contrastively.

[1] This effect was demonstrated by four Kera speakers who were asked to repeat several strings of [ba, pa] syllables. The stimuli had either no difference in F0 or a 7 Hz difference. The Kera rendition either kept the F0 level and made all the VOT values the same, or exaggerated the F0 differences to about 40 Hz.

The question remains why other languages do not take this step. It may be that language contact becomes the catalyst for change.

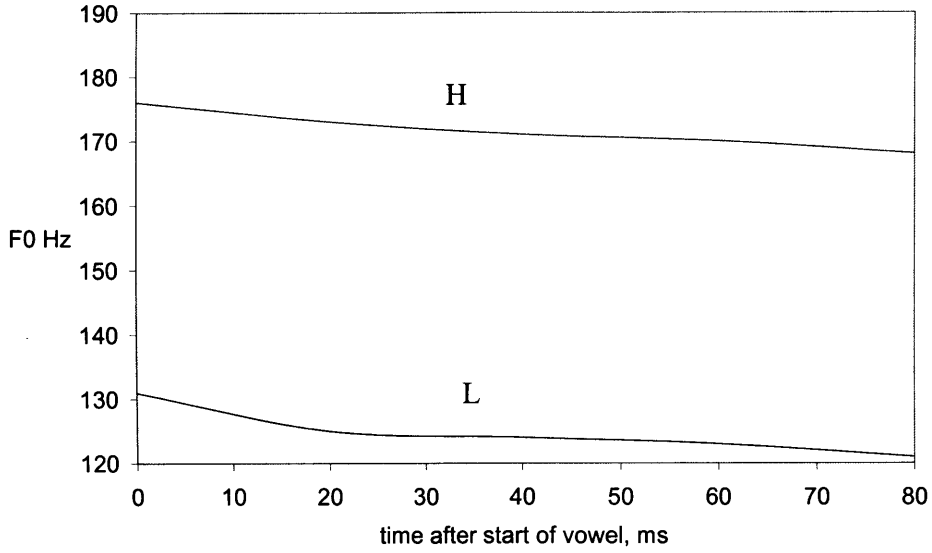
Several linguists have produced pitch tracks showing the perturbations of F0 following various kinds of consonants, in English and in tone languages. Although it is generally accepted that perturbations occur, the tracks from different experiments do not all indicate the same patterns. One of the first, and often cited, studies of these pitch tracks was that of Hombert et al (1979), shown below.

(3) *Pitch tracks following p and b for American English speakers (Hombert et al 1979)*



In a quick experiment to verify if the same patterns occur in Kera, as representative of a tone language, it was found that the patterns are in fact quite different. 100 words were measured, spoken by one Kera speaker. This speaker spoke the standard dialect of Kera (otherwise called the 'Village/Town Men' dialect). As it is not possible to compare 'voiced' with 'voiceless', we compare stops followed by L tone with stops followed by H tone. The results for the different places of articulation were amalgamated as the place did not produce significantly different results. These measurements were taken from heavy syllables in natural speech with the preceding tone the same as the one being measured. Comparing (3) and (4), we note that there is a greater division between the two lines for Kera throughout the measurement and that in Kera, the effect does not wear off as it does in American English. Instead, the tones stay far apart. In Kera and other tone languages, the perturbations are controlled so that the tone for the whole syllable is relatively stable. This is supported by Hombert et al (1979) who claim that there is a tendency in tone languages to actively minimize the intrinsic F0 perturbing effect so that the different tones will be maximally distinct perceptually. So we conclude that the phonetic effects can be overruled in tone languages.

(4) *Pitch tracks following Kera Stops for H and L tones*



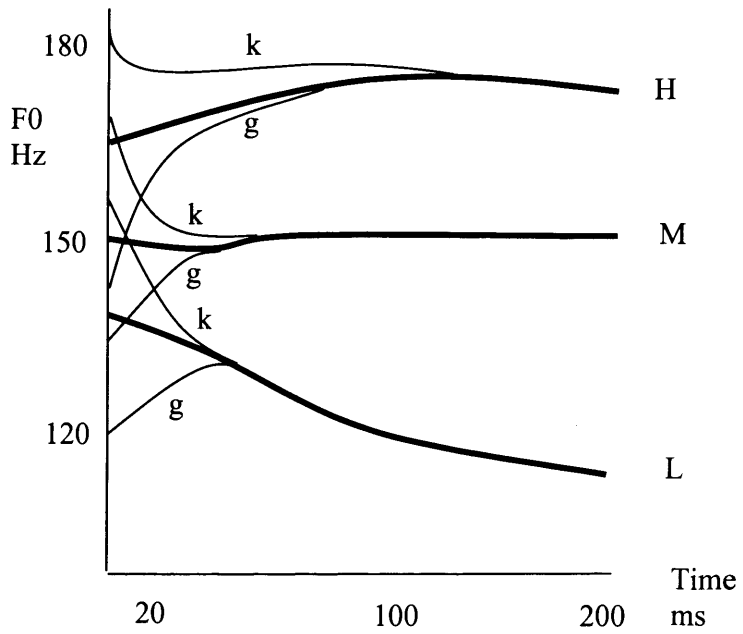
Some languages such as Musey (Shryock 1995) and Kera go further than just developing contrastive tones. In these languages, while the tones develop, the voicing contrasts are lost. Hombert et al (1979) claim that this is the best-documented type of tonogenesis, where the loss of the voicing contrast is the cause of the development of tone. The tone contrasts take over the role of providing the necessary cues for distinguishing between lexical items, compensating for the loss of information when the voicing contrast is lost (Matisoff 1999). Lea (1973) claims that languages can move backwards and forwards between voicing and tone contrast as having both means a high level of redundancy. Other linguists would question whether redundancy is such a driving force and also whether a change in direction is possible. Hyman (1973) for example states that 'Consonants affect tone, but tone does not affect consonants'. Kera would appear to be a counter example to this statement. Proto-Kera apparently developed three tones from a voicing contrast and then lost the voicing contrast. Kera Village Women have three contrasting tones and very little use for VOT. However, in a recent development because of contact with French, the Town Men are losing at least one tone and redeveloping a short/long VOT contrast to replace it. The evidence for these claims can be seen later in this chapter. Hyman would presumably argue that as the relationship between tone and voicing already existed in the tonogenesis stage of Kera, the latest developments are simply a continuation of that relationship with changes in the importance of the two cues as both are affected by the influence of French. However others would interpret these facts as showing that developments in either direction are possible, (Hansson 2004a,b; Poser 1981; Maddieson 1978, p.c.). Hansson gives examples of tone-to-voicing effects from Yabem and Ngizim, and supports this with citations of perception tests which suggest that pitch can cue a voicing categorization (Haggard et al 1970, Abrahamson

and Lisker 1985, Whalen et al 1990), and with a description of Garrett and Hale's (1993) work which suggests that Verner's Law in Germanic may have come from tone-to-voicing effects.

Most of the languages in this survey show evidence of tonogenesis having taken place at some time in the past, but there are two notable cases where synchronic tonogenesis is claimed: In Korean, Silva (2006) claims that the contrast between lax and aspirated is being lost and younger speakers are replacing this with a new tonal contrast. Lax stops trigger the introduction of a default L tone while aspirated and tense stops are realized as H tone. In Kammu, some dialects show a tonal contrast and other dialects show a voicing contrast for the same contrasts. This leads Svantesson and House (2006) to the conclusion that tonogenesis is still in progress. These examples are of interest as we rarely have the opportunity to see tonogenesis in action.

Not all languages develop tones via voicing or VOT influences. Hombert et al (1979) shows that Yoruba has three tones, and for each tone, voiced and voiceless obstruents are permitted. For any one of the tones, there is a slight difference in the pitch track for voiced or voiceless obstruents, with the voiceless track higher, but after 40-60 ms, the two pitch tracks coincide. So it would appear that the three tones of Yoruba were not caused by such a perturbation. In (5), the thick lines indicate the mean average of each tone while the thin lines show the results split for voicing.

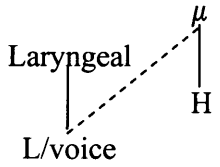
(5) *The effect of stop voicing on tonal pitch in Yoruba (based on Hombert et al 1979)*



Yip (2002) observes that tones have arisen from other laryngeal contrasts in consonants, such as aspiration and glottalization, but that these effects are not as consistent as those of voicing. It should be noted that while I concentrate on tonogenesis from the voicing of the consonants in this thesis, I do acknowledge that there are other ways for tones to develop. For example Schuh (1971) suggests that the tones in Ngizim verbs are affected by the quality of the vowel in the first syllable. A low vowel corresponds to a high tone. Other studies have linked high vowels to high tone in a number of languages (House and Fairbanks 1953). There is also the possibility in some Chadic languages that an accentual system where stress is realized with a higher F0 value developed into a more complicated tonal system. As has been noted with Kera, the contact with other languages is also an important factor in both the loss and introduction of tone. Philip Jaggar (p.c.) believes that Chadic languages developed tone through contact with Niger-Congo languages. It is probable that all these factors had some part to play in the development of the tonal systems of Chadic, and that is why there is a lot of variation.

Linguists differ on how much of a role they think functional load plays in encouraging or suppressing contrasts. Some claim that languages have a tendency to avoid redundant contrasts (Lea 1973). Stevens (2006) claims that languages don't like having two cues with equal force so this might encourage one to diminish when the other gets stronger, and this may be the motivation for languages to lose a voicing contrast at the same time as developing tone. On the other hand it could be the loss of voicing that motivates the introduction of tone. As Matisoff (1999) says, 'Tonogenesis is best explained as a compensatory mechanism for the depletion of consonantal contrasts at syllable-final or syllable-initial position'. However, we cannot say that languages only have tone or voicing but not both. Bradshaw (1999) has a long list of languages that keep both voicing and a tonal contrast with a relationship between the two including Digo, Suma, Siswati, Ewe, Yabem and Vietnamese. Her argument is that tone and voicing are controlled by one laryngeal feature which has different realisations depending on whether it is associated with a consonant or vowel, or both.

(6) *Bradshaw model of the [L/voice] feature on a depressor consonant (1999)*



In this model, the L/voice feature spreads from the consonant onto the vowel. In some languages it displaces or causes the deletion of the tone that is there. In other languages it doesn't spread but blocks any spreading of a H tone through it.

We can find languages at all of the stages that we would expect between voicing and tone. According to Matisoff (1973) pre-6th century Vietnamese had no noticeable tone, but it did have a voicing contrast. In the 6th century the pitch difference was perceived and then from this tones developed in two stages. Glottal sounds in word final position gave rise to 3 tones and these then split into two registers due to the voicing of the initial consonant. In modern Vietnamese the voicing differences remain with cues from creaky voice distinctions, but voicing is less salient. In Karen, a Tibeto-Burman language (Watkins 2001), tone is only partially contrastive; while duration, vowel quality, intensity and spectral tilt all play a role in signalling the contrast. Voicing is not a major cue for this contrast. Maran (1973) claims that the languages Lisu and Akha have both reduced voicing. From early Vietnamese to Akha, there appears to be a continuum of languages in various stages of changing from voice contrast to tone contrast, but there is no evidence that suggests that this is a uniform process. As Yip (2002) observes, it is no longer possible to find out the process for most of the languages cited as the changes took place a long time ago. There is the added problem that the orthography, if there is one, sometimes misleads us as to the role of tone and voicing. This is one area in which this thesis can provide valuable data because it gives a description of a language where there appears to be clear evidence of moves in both directions, with acoustic measurements to back up the most controversial move back to a voicing contrast.

5.2.3 Depressor consonants

In languages that have a consonant/tone connection, the voiced consonants are often referred to as 'depressor consonants'. Not all languages that claim to have these consonants function in the same way. According to Bradshaw (1999), there are various kinds of depressor consonant. There is the well-known type where a depressor consonant is followed by a L tone. e.g. Suma, Mulwi and Yaka, but also spreading or docking of H can be affected by depressor consonants. These consonants can encourage L tone to pass through them or stop the spread of H tone, e.g. Ngizim and Nupe. In other languages they can cause the H tone to shift, e.g. Isixhosa and Siswati, or they can block the movement of H in shifting, docking or spreading. e.g. Siswati, Digo, Bade.

When voiceless consonants appear to have the inverse effect to depressor consonants, they are sometimes known as 'raiser consonants', but this concept is more contentious and the existence of such consonants is not permitted within Bradshaw's analysis.

Before completing this section, it should be noted that research has been conducted into the relationship of tone with other laryngeal features apart from voicing, as seen in the work of Watkins cited above. Hombert et al (1979) cite cases where breathy voiced obstruents act as strong depressors and where implosives are either raisers or non-depressors despite their voicing. The interplay between laryngeal features will be considered further in chapter 6.

5.3 Tonogenesis and depressor consonants in Chadic

The claim of tonogenesis and 'depressor consonants' is common for a number of Chadic languages. Wolff (1987a, 1987b, p.c.) claims this and adds the possibility of 'raisers' (called non-depressors by Wolff). Note that the term 'depressor consonant' is used among Chadicists to refer to the diachronic process of change where phonetic perturbations were interpreted as tonal differences. Among other linguists, the term 'depressor consonant' is reserved for synchronic phonological processes where the voiced consonant encourages or blocks spreading.

Synchronically, the most obvious sign of a relationship is seen where depressor consonants are always followed by low tone. This is the case in Lamang nouns (Wolff 1987a), in Mulwi verbs (Tourneux 1978) and in Musgu (Wolff 1987a). In Musgu there is also a raising effect following raiser consonants.

(7) *Musgu depressor and raiser consonants (Wolff 1987a)*

depressor	L	zìrì	'align'
	L	vìnì	'take'
raiser	H	sírí	'squash'
	H	fíní	'stay'
neutral	L	yìmì	'trap'
	H	yímí	'be beautiful'

Wolff makes the following statement about his understanding of how tonogenesis started in this language; "The last pair of examples shows how tonal contrast development starts off from the neutral class by phonologizing and lexicalizing prosodic alternations of segmental homophones." I have no way of verifying if tonogenesis started with homophones or with obstruent-initial words, although I would expect it to be the latter, and this account still leaves us wondering what the prosodic alternations were and where they came from, but this language gives us some evidence for a relationship between consonants and tone. As in Kera, the existence of a neutral group where any tone is allowed undermines the claim that voicing is affecting tone synchronically. It appears that some tones have come from another

source such as accent, or the tones in the neutral group have changed over time for an unknown reason. What we could say from the above data is that knowing the tone, we can determine the voicing. Whether this holds for the whole language is unclear. But if true, it adds another language to the small group of languages which appear to support the idea of tones influencing voicing, including Yabem (Hansson 2004b) and Kera.

Most Chadic languages seem to have retained a voicing distinction. Wolff (1987a) is not aware of any Chadic languages that have lost voicing contrast. Of course this thesis claims that Kera has done so, and Shryock (1995) claims the same for Musey and Masa, but it still appears that most Chadic languages have retained voicing.[2]

Masa appears to have similar raising and depressing effects to Musey, but the case for a phonological change in Masa is not clear. Barreteau (1995), De Dominicis (2003), and Theda Schumann (p.c.) report that the voice/tone interaction appears to be working at least partly on a phonetic level. The voicing of the onset obstruent affects the F0 pitch track for about 50 ms, after which the target tone for the syllable is achieved. However, similar perturbations are found following some nasals, and a comparison with other dialects shows us that the nasals which have a similar effect to voiced obstruents were at one time prenasalised stops. Even though the nasal is now pronounced without any stop, the phonetic effects are still there in the pitch track. Barreteau (1995) claims that the tonal patterns do provide a phonological contrast involving depressors and raisers with the only neutral consonants being m, n, l, r. De Dominicis (2003) includes more consonants in his neutral group. He claims a first division of the tones into two groups based on a pitch accent, giving H or non-H. Any consonant can be followed by the H tone which marks the accent. In the non-accented case, the tone can be M or L depending on the voicing of the initial consonant. Raisers are followed by M, depressors by L and neutral consonants can be followed by M or L. He therefore claims that all of the surface melodies can be accounted for with depressors and a pitch accent, but that the depressing effects are only seen in non-accented syllables. Not all linguists who have studied Masa agree with him, and it is evidently a language that could do with more research, and detailed phonetic measurements.

In Podoko, depressors also affect the following tone, but in this case the evidence is found in the lowering of a tone that is already classified as L. The L tone is downstepped in the environment of a H tone and a depressor consonant. Anderson and Swackhamer (1981) claim that the L tone itself developed from an exaggeration of the phonetic lowering of the fundamental frequency following voiced obstruents.

[2] Against this claim, we should remember that both Kera and Musey were thought to have voicing until acoustic measurements were carried out, and very few Chadic languages have been subjected to such measurements.

The vast majority of languages which show a relationship between the consonant and the following tone have voiced obstruents followed by L tone and voiceless obstruents followed by H tone. However, a few languages seem to show the opposite trait. i.e. voiced obstruents link with H and voiceless obstruents link with L. For Kanakuru, Wolff (1987a) suggests an explanation along the lines of the Obligatory Contour Principle (OCP).[3] It is not unusual in Chadic languages for only the first consonant in the word to influence the tone through voicing. If we assume this to be the case here, with the tone spreading throughout the word but then being reanalysed as a string of two or more similar tones, then OCP might cause all but the last tone to change. In a 3 syllable word, we might then expect a HLH alternation, but it seems that Kanakuru has a 2 tone limit on the number of tones in a word. (Again this is not unusual in Chadic languages including Kera). To fully explain the present day forms, we have to assume that the voicing/tone relationship is no longer productive in changing tone or voicing. The so called 'neutral' words in (8) are hard to explain. In reality, they do not appear to be neutral, but rather allowing any tone to follow. It is not clear how these tones developed.

(8) Kanakuru reversed system (data and Proto forms from Wolff 1987a)

	Proto form ⟶	OCP ⟶	Present form	
depressor	*dàpè		dápè	'collect'
	*gəmì		gə́mì	'fill'
raiser	*túpé		tùpé	'send'
	*shéní		shèní	'remember'
neutral	*lúkúré		lùkùré	'disprese'
	*làpèrè		lápérè	'hold down'
	*wúpé		wùpé	'sell'
	*wùpè		wúpè	'knot'

Alternatively, the reverse tones could have been introduced because of a different perception as to what is salient in the F0 perturbations. This is an argument that Odden (2005) has suggested for Zina Kotoko which also shows the reverse patterns from the norm. Odden says that there is a lowering of F0 immediately after the voiced obstruent, but very soon afterwards it rises to a higher value than the voiceless equivalent. If this raising effect is exaggerated, then it could eventually be interpreted as a H tone following a voiced obstruent. According to Schuh (1971), Dera also has a tone/voicing link with the reverse pattern from that which is expected. Bradshaw (1999) discusses these languages at length. Her explanation is that the reverse pattern is accidental and not really a reversal. There may

[3] Wolff does not label his rules as OCP, but this is essentially the process that he describes.

have been a relationship between voicing and tone in the past, but this relationship is no longer productive. The tonal patterns have changed and in these languages, the tonal pattern is now stored in the lexicon. Musey (Shryock 1995) also has an apparent reversal in the perfective of the verbs, but as Musey no longer has true voicing, it seems probable that with the loss of voicing there have also been other changes in the tone patterns. It is still a mystery however how the following patterns developed. Note that in the imperfective, we get the expected pattern, but in the perfective, it reverses.

(9) *Musey apparent reversal of normal tone patterns (Shryock 1995)*

	Imperfective	Perfective	
High set	tó	tō	'sweep'
	kál	kāl	'enter'
	hórōk	hōrōk	'farm'
Low set	dō	dó	'pick off'
	zāl	zál	'wash again'
	vārāk	várāk	'replace'

Shryock claims that in Musey, the three tones can go with either set of consonants, but the formerly voiced set are followed by a slightly lower tone than the voiceless set. The phonetic effect lasts for the length of the vowel although the two tracks converge. This brings into question whether the tones first came into being in Musey through differences in voicing or through some other means such as word accent. Although it seems clear that there was diachronically a voicing contrast, it appears to be independent of the tonal patterns.

As well as languages where the consonant directly affects the choice of tone on the following syllable, there are other Chadic languages where the relationship is observed in the blocking of spreading. In these languages, a voiced obstruent can be adjacent to a H tone, but a H tone will not be able to spread through the voiced obstruent. A clear case of this is found in the Chadic language of Bade (Schuh 2002b, Schack Tang 2006). Bade has two tones, and both voiced and voiceless obstruents appear to block tone spreading. In the verb, H spreads left-to-right across all consonants except phonologically voiced obstruents, while L spreads across all consonants except phonologically voiceless obstruents.

(10) *Bade tone spreading and blocking (Schack Tang 2006)*

H tone spread:	/nə̀ tə̀nkə̀kú/	> nə́ tə́nkə́kú	'I pressed'
H tone spreading blocked:	/nə̀ tə̀mbə̀lú/	> nə́ tə́m**b**ə̀lú	'I pushed'
L tone spread:	/dʒə̀ kə̀rə́ kó:rón/	> dʒə̀ kə̀rə̀ kó:rón	'we stole a donkey'
L tone spreading blocked:	/dʒə̀ gàfá kó:rón/	> dʒə̀ gàf̃á kó:rón	'we caught a donkey'

According to Schuh (1971), Ngizim (Western Chadic) has a similar system where H spreading is blocked by depressor consonants and L spreading is blocked by raiser consonants. Hansson (2004a,b) remarks that there is clear evidence of the interdependence of voicing and tone in Ngizim.

Several laryngeal features can play a part in the contrast. Musey (Shryock 1995) has two sets of contrasting obstruents, but both sets are voiceless and the difference in VOT is around 10 ms which is less than the amount which is considered to be detectable. There is also no real durational difference between the two. But Shryock has found differences in a combination of cues including the amplitude, the burst amplitude, the F0 of the following vowel, the voice offset time and the spectral tilt of the following vowel[4]. So he concludes that there is a contrast here. It seems likely that historically there was a voicing contrast but the voicing has been lost while leaving a contrast that is marked mainly by tone, but with a few other cues remaining to enhance this contrast.

We have seen that Zina Kotoko has clear signs of depressor consonants even if the tonal patterns are a reversal of what we expect in some cases. Despite this reversal, Odden (2005) still describes how depressor consonants lower the following tone, with H changing to M and M changing to L, and he claims that the preceding tone also changes from M to L. Tourneux (2003) has researched comparative data from other languages in the Kotoko group. Of these, Afadé has mostly H tone words and Mattam and Makari have mostly L tones on the same items of data. None of these show real signs of a voicing/tone interaction. But the three languages Makari, Kouseri and Logone[5], all of which are closely related to the others, do show hints of an interaction. In each of these languages, there are initial consonants with the opposite setting for voicing than all the other languages in the group, and the change coincides with the appropriate tone. It is conceivable that all of these languages developed tone through a voicing/tone interaction, but then three of them completely obscured the evidence by introducing further tones which were not subject to

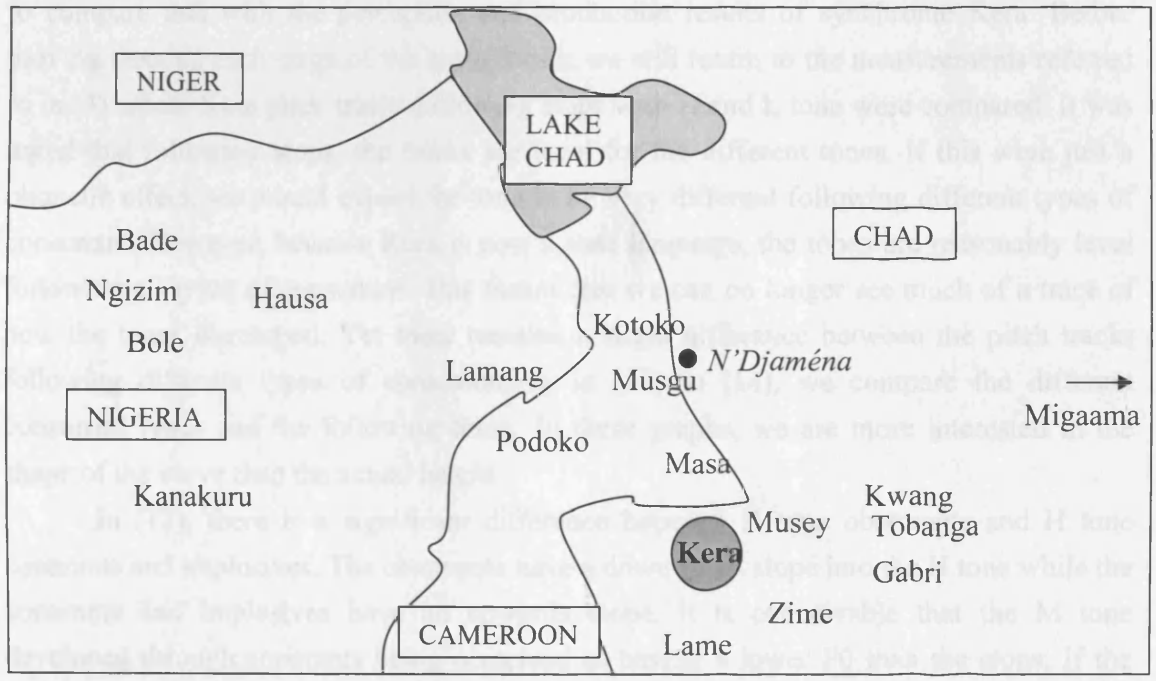
[4] A brief investigation into these cues in Kera showed that they were not as significant as F0 and VOT, although they undoubtedly contribute to the perception of contrasts in a minor way. So in this thesis, I have chosen to concentrate on the two main cues. However, it is an area for further research, especially the voice offset time which is a major cue in Musey.

[5] Logone is otherwise known as Lagwan. There are more references to this language in chapter 4.

any agreement with voicing. It is unlikely that any voicing/tone interaction is productive now in any of these languages, but there does seem to be a suggestion that it was present diachronically.

Wolff (1987a) has noted that the Chadic languages which show clear signs of consonant/tone interference have a central position geographically in the region where Chadic languages are spoken. This means that in Central Chadic languages, the Masa group and the westernmost Eastern Chadic languages such as Kera, the relationship is generally clear. It is true that some Central Chadic languages do not exhibit any obvious signs of the tone/voicing relationship. These include Parekwa, Zelgwa, Mofu-Gudur, Giziga, and Kada (Barreteau 1995). It may be that they developed tone through an accent system or through contact with other languages, or they could have undergone tone/voicing interference which has since been obscured by voicing and tone undergoing further changes.

(11) *Map of area where Chadic languages are spoken with a selection of languages*



Wolff assumes that all Chadic languages underwent tonogenesis from the voiced consonants but that the outer languages have developed further, maybe through contact with other languages, or with changes from an accent system, and that the voicing/tone evidence has been lost. He rejects the idea that language contact was involved in any of the tonogenesis, but as most tonal changes in the world have involved contact (Gussenhoven 2004, Aitchison 2001), it seems wise to keep this as an option.

It would be beyond the scope of this thesis to prove any of these claims, but we have seen that the voicing/tone relationship is an important part of tonal development in Chadic. Proto-Chadic reconstructions carried out by Stolbova (1996, 2005) suggest that voicing was contrastive even at an early stage of the development of Chadic languages. The same cannot be said for tonal contrasts. There is a long-standing debate as to when Chadic languages became tonal (Wolff 1987b, Blench p.c.). But there is consensus that at some point the language was non-tonal.

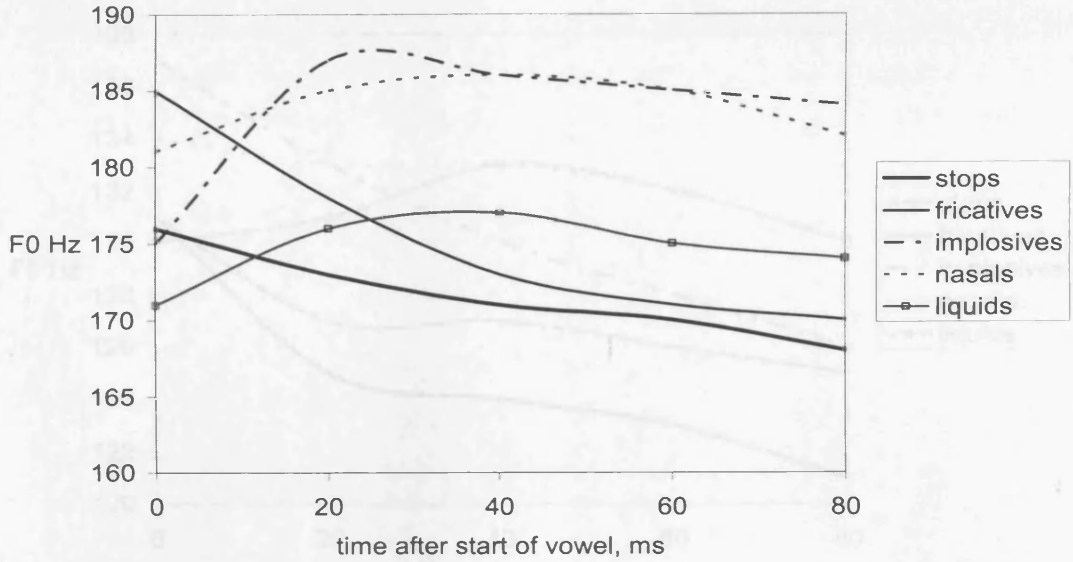
We now examine the claims for tonogenesis in Kera. We will refer to this account again in chapter 6 when we come to analyze the various contrasts at each stage. Any account of tonogenesis has to be partly conjecture, but once we get to the synchronic system, all claims will be supported by detailed acoustic measurements.

5.4 Kera tonogenesis

The aim in this section is to give a possible account of what happened so that we can go on to compare this with the perception and production results of synchronic Kera. Before moving through each stage of the tonogenesis, we will return to the measurements referred to in (4) where Kera pitch tracks following stops with H and L tone were compared. It was noted that following stops, the tracks are level for the different tones. If this were just a phonetic effect, we would expect the tone to be very different following different types of consonant. However, because Kera is now a tone language, the tones are reasonably level following all types of consonant. This means that we can no longer see much of a trace of how the tones developed. Yet there remains a slight difference between the pitch tracks following different types of consonant, so in (12) to (14), we compare the different consonant types and the following tones. In these graphs, we are more interested in the shape of the curve than the actual height.

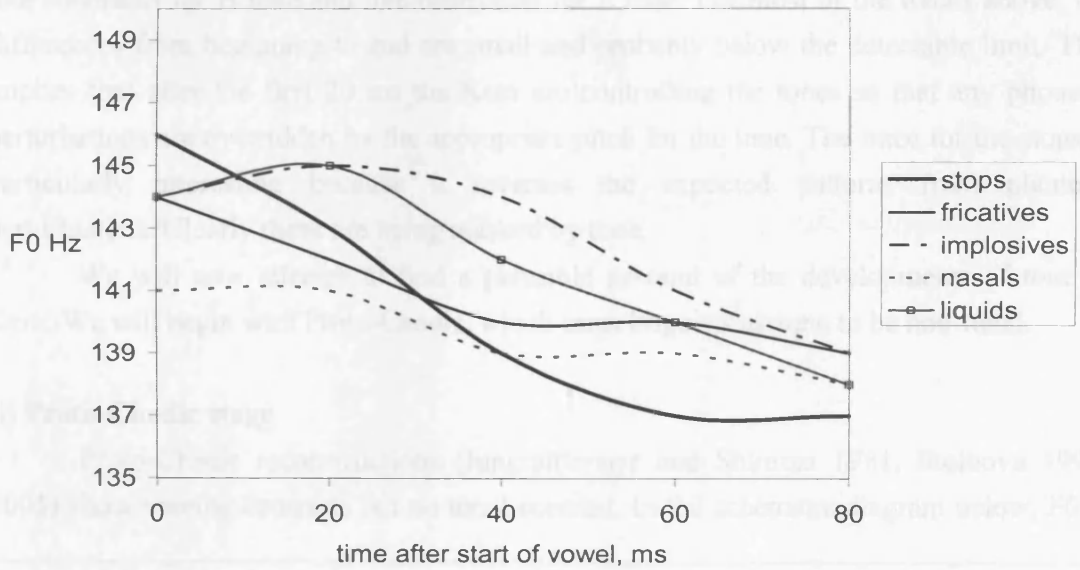
In (12), there is a significant difference between H tone obstruents and H tone sonorants and implosives. The obstruents have a downwards slope into the H tone while the sonorants and implosives have an upwards slope. It is conceivable that the M tone developed through sonorants being perceived as having a lower F0 than the stops. If the listener concentrated on the initial F0 value, he could conclude that Kera has H and M tone with obstruents being followed by H tone and sonorants by M. This conjecture about M tone development will be discussed further in our account of Kera tonogenesis.

(12) *H tone*



For M tone, there is no clear difference between consonants. All consonants are followed by a gently falling pitch track, although implosives and sonorants have a slight initial rise.

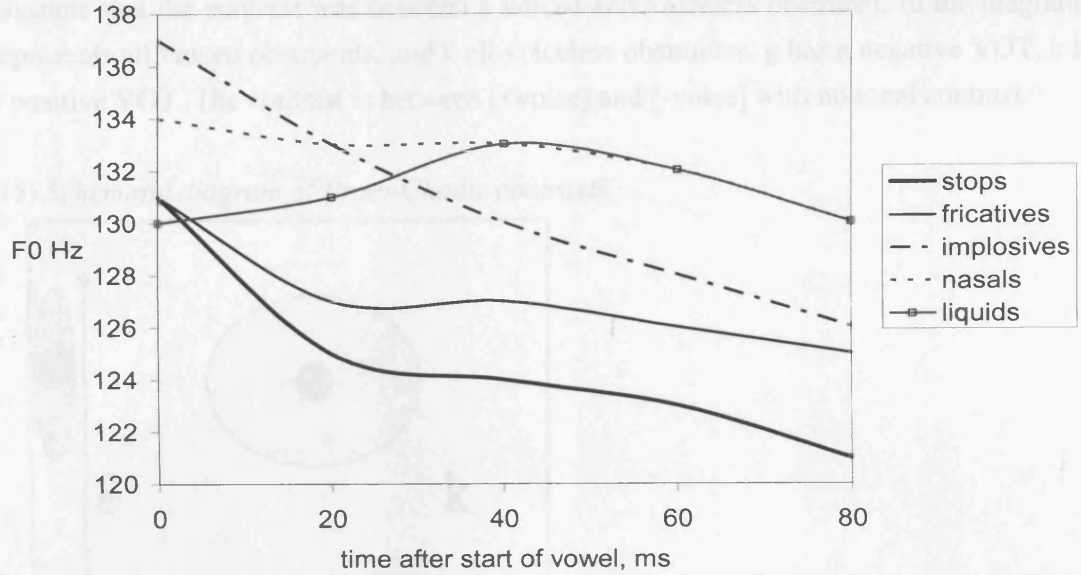
(13) *M tone*



For the L tone pitch tracks, there is again a difference between the consonant types, with sonorants being followed by a relatively level tone while obstruents and implosives are followed by a falling pitch track.[6]

[6] Comparing the behaviour of implosives for H and L tone, these graphs could support the idea that Kera had two types of implosive diachronically. Across the literature, both types of implosive are claimed in Chadic

(14) *L tone*



Comparing all three of the graphs above, we find that stops and fricatives are followed by a falling pitch track at all tones, while sonorants have a tendency to be followed by a rise. The only consonant that has a markedly different behaviour is the implosive which behaves like sonorants for H tone and like obstruents for L tone. For most of the tracks above, the differences from beginning to end are small and probably below the detectable limit. This implies that after the first 20 ms the Kera are controlling the tones so that any phonetic perturbations are overridden by the appropriate pitch for the tone. The trace for the stops is particularly interesting because it reverses the expected patterns from phonetic perturbations. Clearly these are being masked by tone.

We will now attempt to find a plausible account of the developments of tone in Kera. We will begin with Proto-Chadic, which most linguists assume to be non-tonal.

(i) Proto-Chadic stage

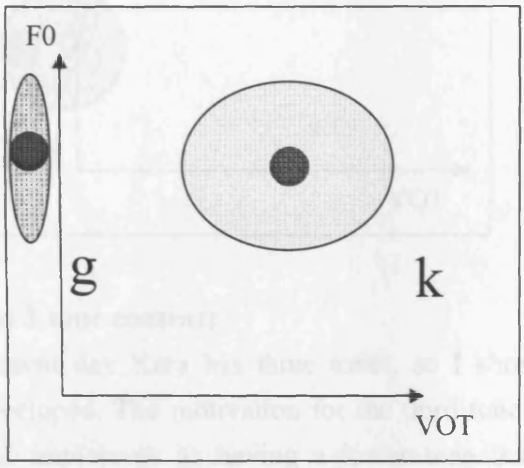
Proto-Chadic reconstructions (Jungraithmayr and Shimizu 1981, Stolbova 1996, 2005) show voicing contrasts but no tonal contrast. In the schematic diagram below, F0 is

---

languages (Avery and Idsardi, forthcoming) and Hansson 2004b notes that several Chadic languages treat implosives as neutral rather than as depressor consonants associated with L tone. Hyman and Schuh (1974) put implosives at the top of a hierarchy of consonants that induce tone raising effects and Ohala (1973) and Hombert (1978) give support for this. Odden (2005) remarks that this is the concensus in Chadic languages too, but his discussion on Zina Kotoko suggests that implosives can act as depressors in M tone lowering. So it looks as though there may be a case for two kinds of implosive, but there is not enough evidence for this to be more than conjecture in the case of Kera, so we will not take this further here.

plotted against VOT. We have no data from this stage in the development of Kera, but we presume that the contrast was between a voiced and voiceless obstruent. In the diagram, g represents all voiced obstruents, and k all voiceless obstruents. g has a negative VOT, k has a positive VOT. The contrast is between [+voice] and [-voice] with no tonal contrast.

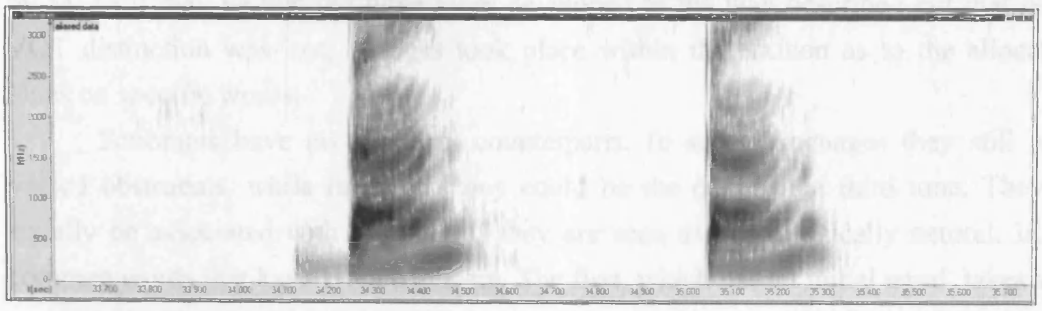
(15) *Schematic diagram of Proto-Chadic contrasts*



This kind of contrast is seen in (16) for a French minimal pair.

(16) *French minimal pair:*

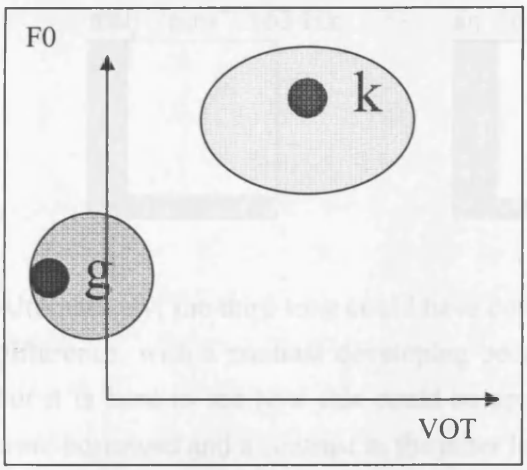
bain 'bath'	pain 'bread'
[b] VOT -121ms,	[p] VOT 11ms
Prevoiced	Positive VOT



(ii) Tonogenesis

We assume that the F0 perturbations following voiced obstruents became larger as a difference in tone was perceived. Contrastive tone developed, co-varying with the voicing contrast. Voiced obstruents had L tone, while voiceless obstruents had H tone. At this point the relationship between tone and voicing would fit well with Bradshaw's (1999, 2000a, b) claims that there is one contrastive feature combining tone and voicing. The contrast is now L/+voice and H/-voice.

(17) *Schematic diagram showing tone/voicing contrasts*



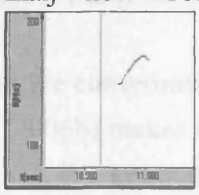
(iii) 3-tone contrast

Present day Kera has three tones, so I should have some story for how the third tone developed. The motivation for the third tone could have been the perception of sonorants and implosives as having a lower tone than voiceless obstruents. This comes from a delayed peak for H following sonorants. So words with voiceless obstruents developed into H while sonorants developed into M (and voiced obstruents linked to L tone). This would have been accompanied by loss of voice so a 3 way tonal contrast developed and the VOT contrast disappeared. If this account is correct then I would expect H and L tones to have obstruent onsets and M tone to have sonorant onsets. In present day Kera, obstruents and sonorants are found preceding all tones, but there is a tendency for sonorants to be followed by M, so it may be that the three tones developed in the way described but that once the VOT distinction was lost, changes took place within the lexicon as to the allocation of tones on specific words.

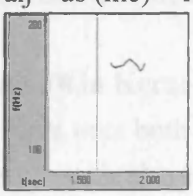
Sonorants have no voiceless counterparts. In some languages they still act like voiced obstruents, while in others, they could be the cause of a third tone. They could equally be associated with any tone if they are seen as phonologically neutral. In (18) I compare words that have H tone in Kera. The first, which has an initial nasal, takes a while to reach the H tone F0 value. In contrast to this, the second and third, which start with a glottal stop and a velar stop, do not take any time to reach the H tone level.

(18) *Sonorants start with a lower pitch*

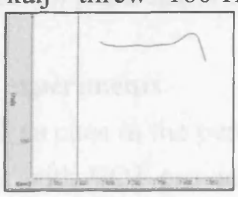
mán̩ 'now' 163 Hz



án̩ 'us (inc)' 163 Hz



kán̩ 'threw' 160 Hz



Alternatively, the third tone could have come from a secondary split through an allophonic difference, with a contrast developing because of the deletion of a conditioning segment, but it is hard to see how this could be applied to Kera. Another possibility is that words were borrowed and a contrast in the other language was borrowed with them.[7] For this to be the case there would have to be a two or three-tone language with sonorant words contrasting to borrow from. Masa and Musey both have sonorant tonal contrasts and inter-marriage would cause language contact. We do not know which languages were geographically close to the Kera people in the past. There is evidence of migration from an area around Egypt, so it is impossible to go beyond speculation in recreating this history. What we can say is that three tones developed and that the voicing contrast was lost.

(19) *Schematic diagram showing 3-way tonal contrast*

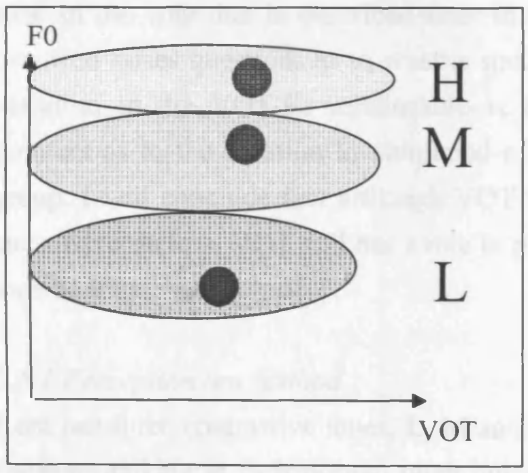


Diagram (19) represents village Kera as it is today. Further changes have taken place through contact with French, but before considering this, we will look at a perception experiment with subjects from the three languages Kera, English and French. I will start

[7] The verb *kēyé* 'help' is reported to be borrowed. This verb has non-alternating M tone, demonstrating that new tonal patterns can come from loans.

with a description of the experiments and then we will consider comparisons between the languages. Finally we will look in more detail at the differences within populations of Kera.

5.5 Relative contribution of VOT and F0 in Kera: Perception experiments

Pearce (2006b) makes the claim that Kera uses both F0 and VOT as cues in the perception of voicing. We know that English and French also use both cues with VOT providing the contrast while F0 has a minor supporting role, but in Kera, the roles are reversed; F0 is of primary importance as tones are underlying and distinct, while for most of the Kera speakers VOT is an enhancing cue. The amount that VOT is used depends on certain factors such as location. Kera is undergoing change particularly in town, with less dependency on tone and more on VOT. In the remainder of this chapter, we will examine the results of the perception and production tests which support these claims. We will find that the use of VOT and F0 varies according to the location of the speaker in childhood, the gender of the speaker and their literacy level. We will consider how F0 and VOT are used to convey contrastive tone and how the cues prompt the listener when the speaker raises or lowers the tone register or changes the speed of delivery. This study will give us some pointers as to how the relationship between these two cues may have come about historically. Some of the changes are unusual. Labov (pers. comm.) has commented that generally he would not expect contact with a language with voicing to have an influence on tone in the way that is described later in this chapter. The fact that these changes have occurred raises questions as to what is special about the Kera case. A side product of the variation in the VOT/F0 relationship is that it gives the listener some sociolinguistic pointers as to the location in childhood of the speaker, and possibly his preferred social group. I will conclude that although VOT is for most speakers the less salient of the two cues, nevertheless, VOT still has a role to play in enhancing communication by making the tone contrast more robust.

5.5.1 Perception test method

Kera has three contrastive tones, L, M and H with an F0 range of 100 to 160 Hz for male speakers talking at their normal pitch range. The VOT of obstruents alters between 0 ms and 60 ms in normal speech. The following perception test (Pearce forthcoming) was designed to measure how much VOT and how much F0 is used in voicing judgements. The test was run on 32 Kera, 16 English and 5 French subjects. All subjects were aged between 14 and 60, the majority were aged between 20 and 40. Kera subjects were divided into groups according to location, gender and literacy level. Men were divided into three groups:

a. Village Men: Those who were brought up and still live in the village.
b. Village/Town Men: Those who started in the village, but who moved to town after the age of 16
c. Town Men: Those who were brought up in town.

Women were divided into two groups (although some of the results are combined):

a. Village Women
b. Town Women

The age of 16 was chosen for the division between the male categories as this age appeared to give the most dramatic results (demonstrated in (71)). But there is a continuum from village to town so other ages could have been used with similar results. The age of 16 also has the advantage of splitting these two groups roughly in two.

The perception test was set up using the Kera words *kɛ:*, *pi:*, and *ta:*. A recording of these words was made, spoken by a Kera man. These tokens were then manipulated in PRAAT and resynthesized using PSOLA to produce tokens with 6 levels of VOT and 6 levels of F0 covering the normal male range for both of these. The VOT values ranged from 5 ms to 55 ms and the F0 values from 100 Hz to 150 Hz. These tokens were then randomized and each was included twice in the test, giving a total of 216 tokens. All subjects, regardless of language, were given the same tokens. For the Kera speakers, the words *kɛ́:* 'throw (habitual)', *gɛ̀:* 'throw (once), *pí:* 'pick up', *bì:* 'come', *tá:* '3 person sg fem. emphatic pronoun', *tā:* 'emphatic marker' and *dà:* 'direction marker' are all real words. The subjects' task was to listen to the token and to decide between the choice of two transcriptions according to what they had heard. So for example, a choice between <ke> and <ge> would be presented to them. Kera non-readers were given pictures representing the words instead of the written form and they were asked to point to the picture of the word they had seen. (The mid tone word *tā:* was not represented in the pictures). They showed no difficulty in understanding the pictures and completed the test at the same rate as the readers. The results were analysed using ANOVA to check for significance.

The same Kera tokens were presented to the English and French speakers. These words had no meaning for them, but the test assumes that the English and French subjects could still make voicing judgements. The English were measured mainly to provide a comparison with a non-tonal language that has a similar VOT range to Kera. The French results were collected because a number of Kera have been influenced by speaking and reading French in school and in the market. This thesis claims that this contact with French has affected their Kera.

5.5.2 Perception test results – comparison of languages

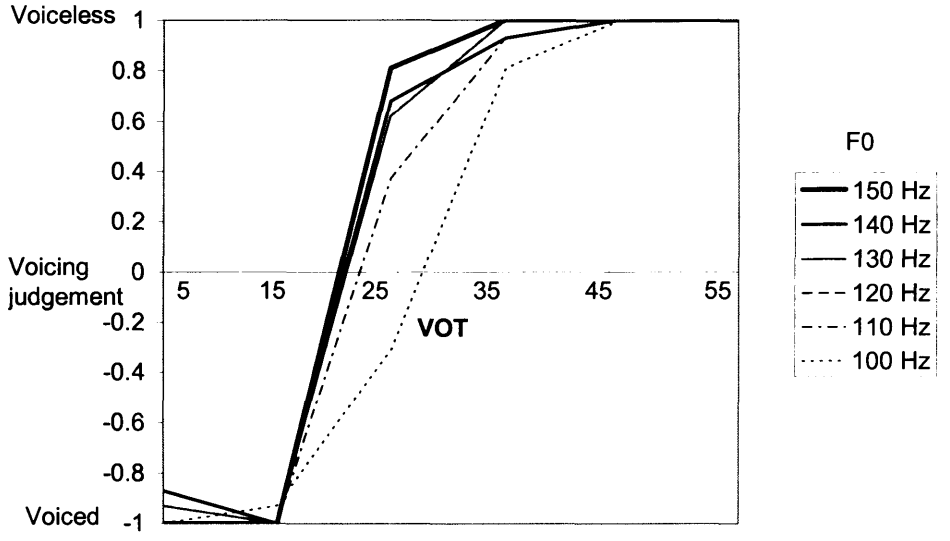
I will start with the English results.

5.5.2.1 English

Graph (20) shows the English results for alveolar stops in the voicing judgement, the VOT values are plotted against the voicing judgement. For any given VOT value, a judgement of 0 means that half of the tokens were judged to be voiceless and the other half voiced, a judgement of -1 implies that all tokens were judged as voiced and a judgement of 1 implies that all tokens were judged to be voiceless. The graph contains 6 lines of various thicknesses. These indicate the different F0 values of the tokens, with a thick line indicating the highest F0 and the thinnest line the lowest.

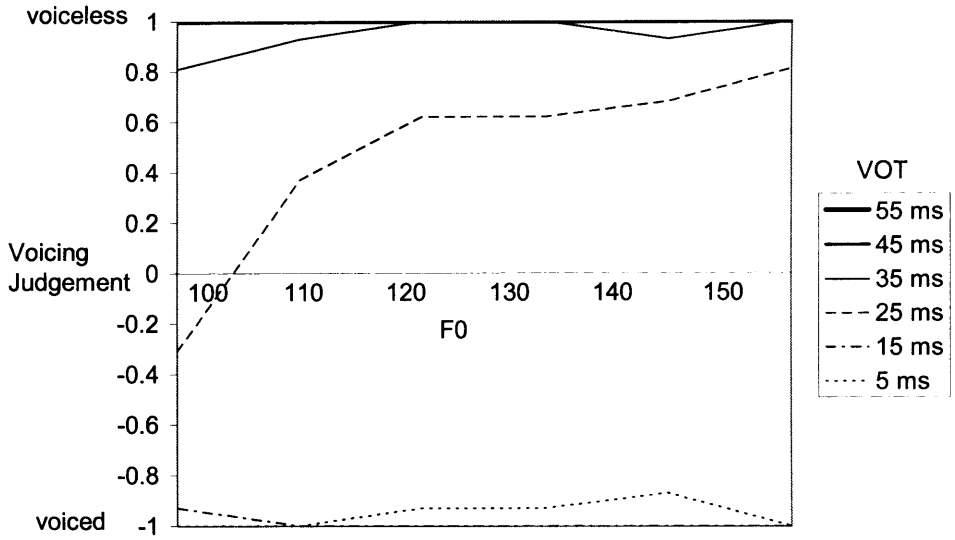
The lines trace a clear S shape, indicating a sharp categorization between voiced and voiceless. This shows that in English, VOT plays a major role in the voicing perception, whereas the closeness of the 6 lines indicates that a change in F0 makes very little difference.

(20) *English VOT/voicing judgement for t/d*



In the next graph, the VOT value is replaced by the F0 value on the x-axis and the VOT values are now indicated by the various thicknesses of the lines. The horizontal lines in this graph confirm that the F0 has only a minor role in voicing perception. This graph shows us that in perception the F0 is only used in ambiguous (middle VOT) values. At the extremes of VOT, F0 makes no difference and judgements are at ceiling (so the lines are superimposed on each other at the top of the graph).

(21) *English F0/voicing judgement for t/d*

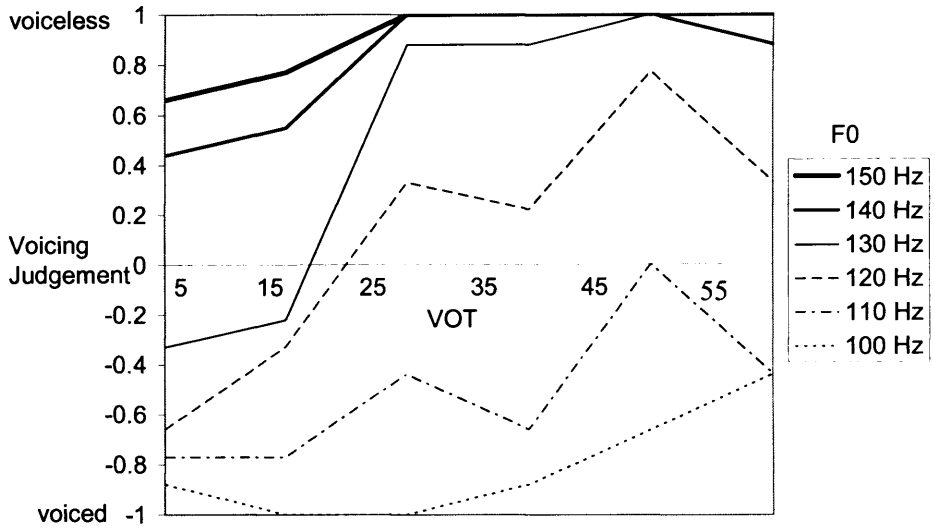


The two graphs above show the results for alveolar stops. Other places of articulation give similar results (see appendix 2).

5.5.2.2 Kera

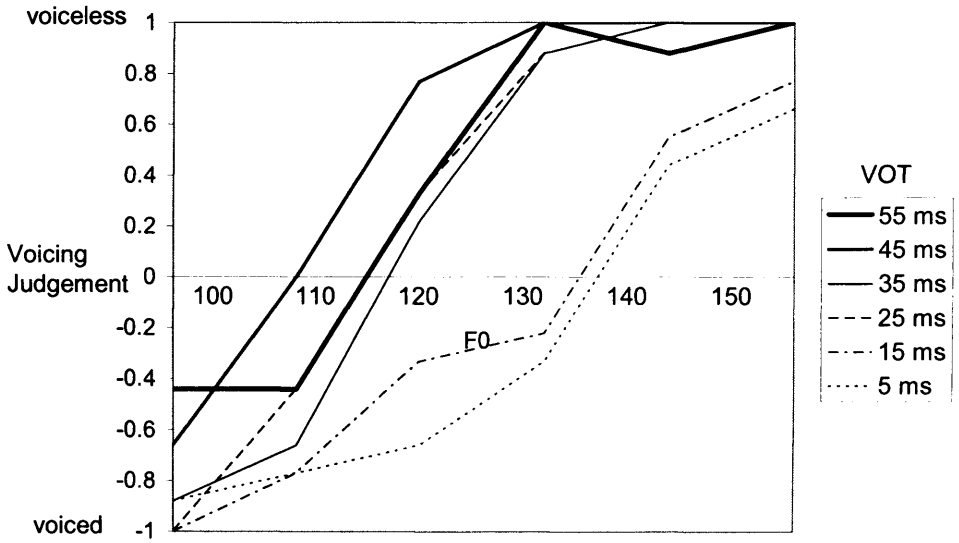
We now consider the Kera results. At this point we will look only at the results for village men who moved to town as adults (Village/Town Men), taking this to be the standard Kera dialect. The following graph should be compared with the first English graph (20). In place of a highly categorical S curve, we have a much flatter set of lines (somewhat like the English F0 graph (21) although with more variation in the middle range). This means that the VOT value does not play a major role in voicing perception for these Kera speakers.

(22) *Kera VOT/voicing judgement, for t/d, Village/Town (9 subjects)*



The next graph shows that the F0 values are more important than VOT in voicing judgements. The S shape indicates the categorization that takes place according to the F0 value.

(23) *Kera F0/Voicing judgement for t/d, Village/Town (9 subjects)*

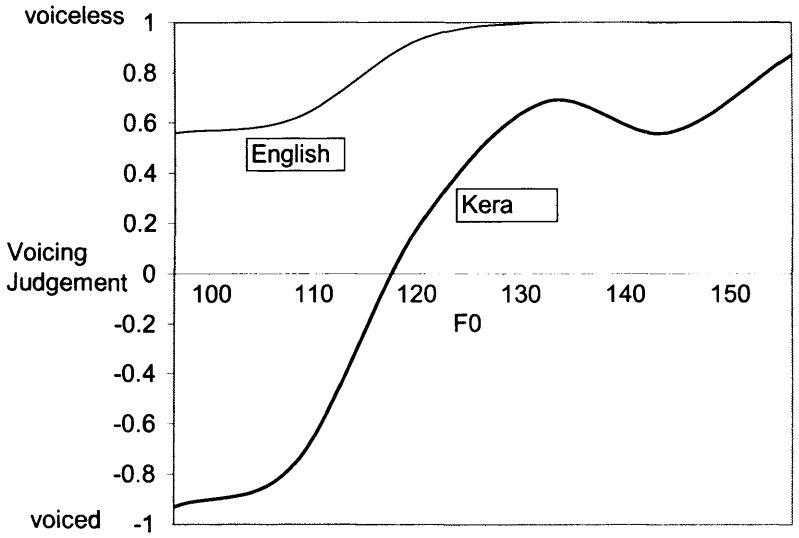


The graphs for English and Kera are in some ways a reversal of each other, showing that in Kera the F0 cue is important in the voicing judgement, while VOT is much less so. Again the results for other places of articulation are similar (see appendix 2).

5.5.2.3 Comparison between languages

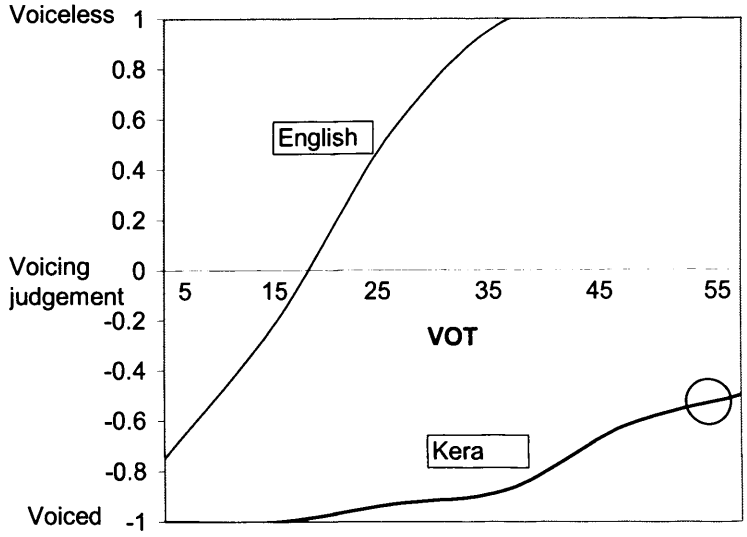
In English, the VOT effect is much larger than the F0 effect, but the F0 value still has some influence in ambiguous cases. In Kera, the F0 effect is larger than the VOT effect, but again the VOT value is still used in ambiguous cases in the middle of the range. To see the contrast, consider fixing VOT at 35 ms for p/b. We then take the 35 ms plot from the p/b equivalent of (20) and (22) and combine them in one graph. The English judgement, shown by the thin line in (24), does not change much whatever the F0. But the Kera judgement, indicated by the thick line, covers almost the whole range of judgements depending on the F0 value.

(24) *Comparison of English and Kera voicing judgements for p/b if VOT fixed at 35 ms, but F0 varies.*



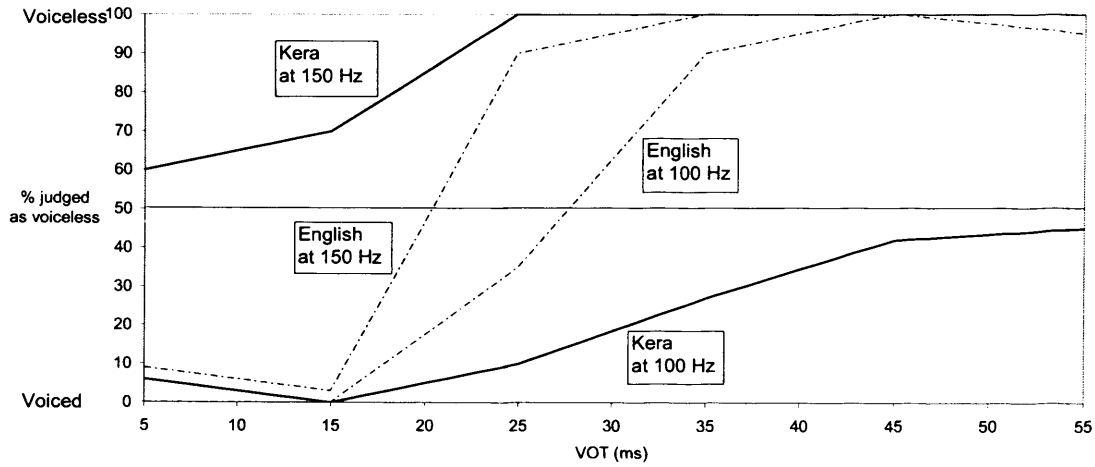
Now consider fixing the F0 value at 100 Hz for p/b. (25) shows that the English judgements cover the whole range depending on the VOT, while the Kera judgements don't change much whatever the VOT. There is an interesting implication from this graph. If the Kera hear [pi] said with a long VOT at the low F0 value of 100 Hz, it is perceived as voiced 75% of the time, as indicated by the circle. English speakers hearing the same token would be totally convinced that it is voiceless.

(25) *Comparison of English and Kera voicing judgements for p/b, if F0 fixed at 100 Hz, but VOT varies.*



The fixed points used in graphics (24) and (25) have been chosen to illustrate the contrasting systems, but the differences between English and Kera are also seen clearly if we compare the extreme values of the judgements. We look first at the voicing judgements at the two ends of the F0 range. If F0 has little effect, the judgements should be roughly the same at F0 = 100 Hz and F0 = 150 Hz. This is true in English, as the dotted lines in (26) show (one at 100 Hz, the other at 150 Hz). On the other hand, if F0 has a strong effect, the judgements of voicing should be very different at 100 Hz and at 150 Hz. This is true in Kera, indicated by the solid lines (the bottom line at 100 Hz, the top line at 150 Hz). The t/d graph is presented here, and the graphs for p/b and k/g can be seen in appendix 2.

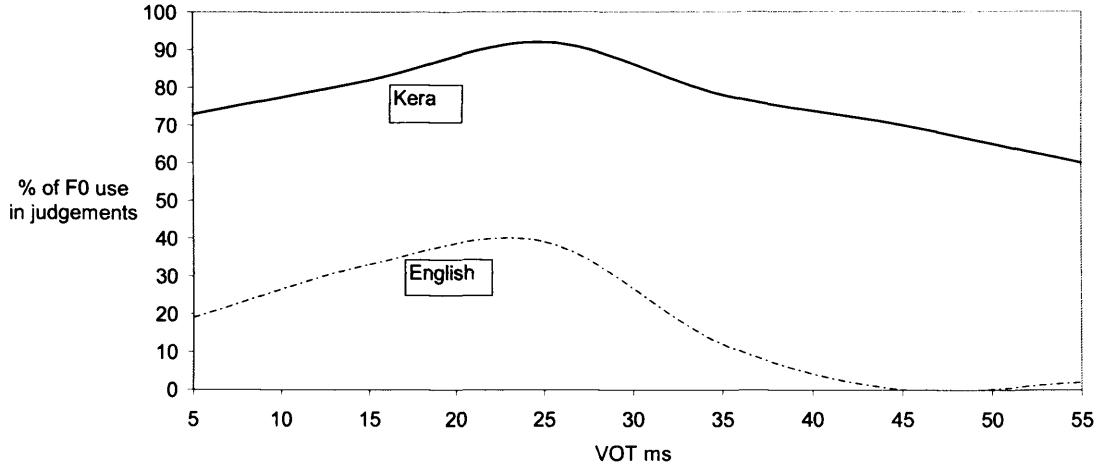
(26) *Comparison of English and Kera at extreme values of F0, t/d*



I conclude that for Kera, VOT has a limited effect on voicing judgement while F0 has a major effect. The reverse is true for English.

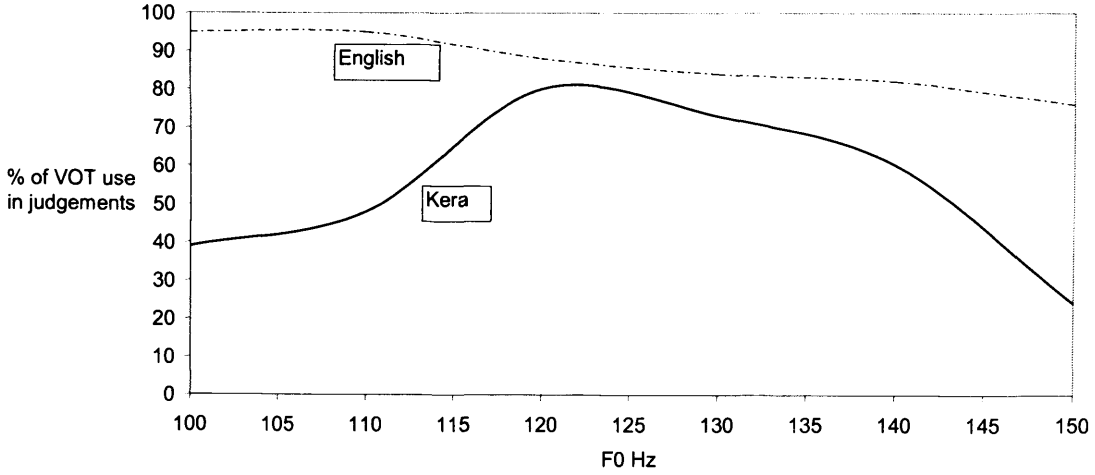
Another way to compare the data involves calculating the percentage difference between the voicing judgement for F0 = 100 Hz and F0 = 150 Hz for each of the places of articulation as a percentage of the whole available range of judgements. In this way we can compare the role of F0 in voicing judgements for the two languages over all places of articulation.

(27) *Comparison of English and Kera, role of F0*



A similar calculation combining the percentage difference between the voicing judgement for VOT = 5 ms and 55 ms for each place of articulation gives us the role of VOT in voicing judgements.

(28) *Comparison of English and Kera, role of VOT*



These graphs lead us to conclude the following use of VOT and F0 in the perception of voicing judgements:

(29) *Comparison of English and Kera – use of VOT and F0*

	VOT	**F0**
English	Major	Ambiguous cases only
Kera	Ambiguous cases only	Major

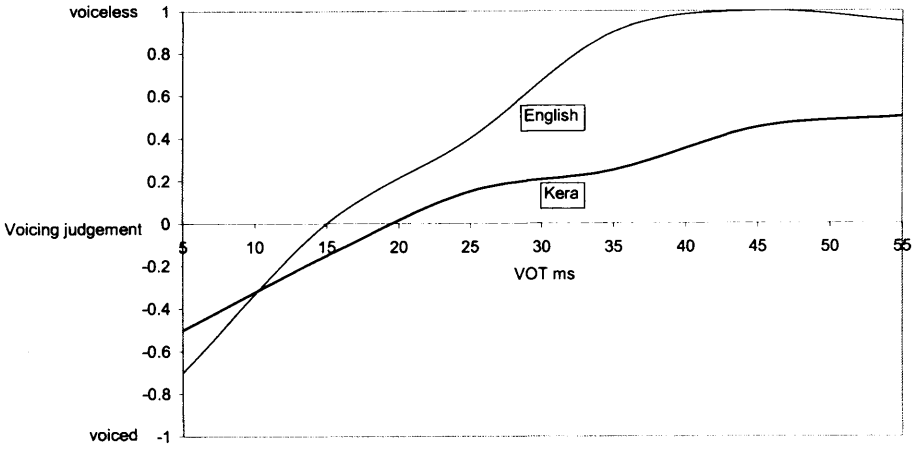
In summary, we have found that in English, the VOT is contrastive while F0 enhances or supports the VOT, whereas in Kera, the F0 is contrastive and VOT enhances the tone. The enhancement means that the VOT in Kera enables an improved level of perception of tone. Roughly speaking, Kera and English have role reversal between VOT and F0.

These results were subjected to statistical tests for significance. The perception test involved two trials of each item and the responses were collated on a scale of 0,1,2. This scale was used as an independent variable in ANOVA with the three factors of language, VOT, and F0. (In the graphs, the scale has been transposed to -1 to 1 so that if the majority of judgements are voiced, this gives a negative result, while if the majority of judgements are voiceless, this gives a positive result). The Greenhouse-Geisser correction test was employed to counteract the effect of the S-shaped graphs. The results of these statistical tests were as follows:

For the p/b test in both languages, there was a major effect between the languages in their use of VOT and F0: $f(1,30)=92.78$, $p<0.001$.[8] Therefore we are right to conclude that the two languages use these cues differently. The mean value for English voicing identification on the 0 to 2 scale is 1.672, whereas the Kera mean is 1.120. In English, the effect of VOT is dramatic and performance reaches ceiling at 35ms. The effects of F0 are therefore limited to VOT = 0-35ms (see (30) below). (30) is similar to (25), but in (30), the graph covers all of the data for all places of articulation and all values of F0. Note that for English, the curve is an S-curve, but the first bit of the curve is not shown as VOT measurements started at VOT = 5 ms.

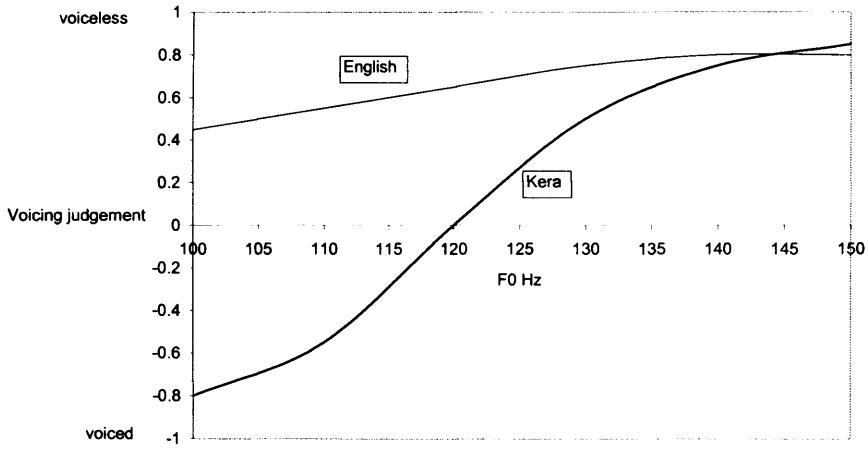
[8] The ANOVA tests also showed that across the two languages there was a major VOT effect: $f(2.27,68.0)=110.38$, $p<0.001$, and a major F0 effect: $f(3.11, 93.3)=201.73$, $p<0.001$. Clearly for both languages, both of these cues are important.

(30) *Comparison of English and Kera for VOT use in voicing judgement*



Across the F0 range English averages a uniformly high rate of voiceless judgements and variation in the voice detection is not very significant. For Kera, the F0 value makes a major difference to voice perception. This is shown in (31). This graph has similarities to graph (24) but is now covering the whole range of places of articulation and all values of VOT.

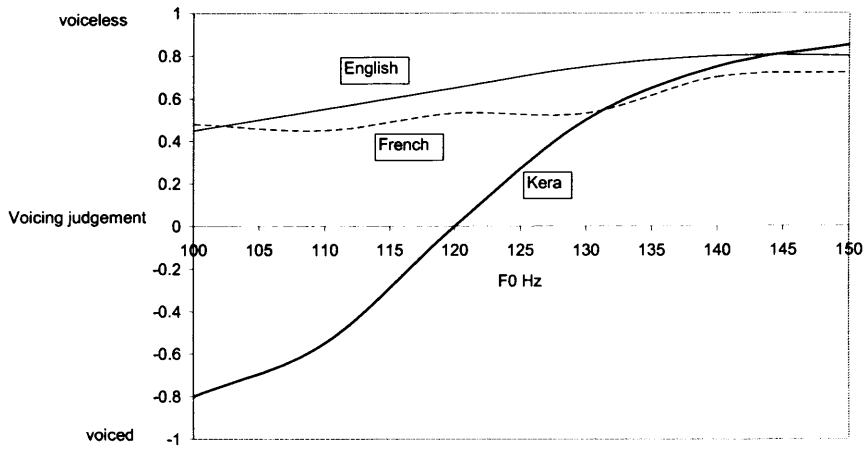
(31) *Comparison of English and Kera for F0 use in voicing judgement*



5.5.2.4 Comparison between French and Kera

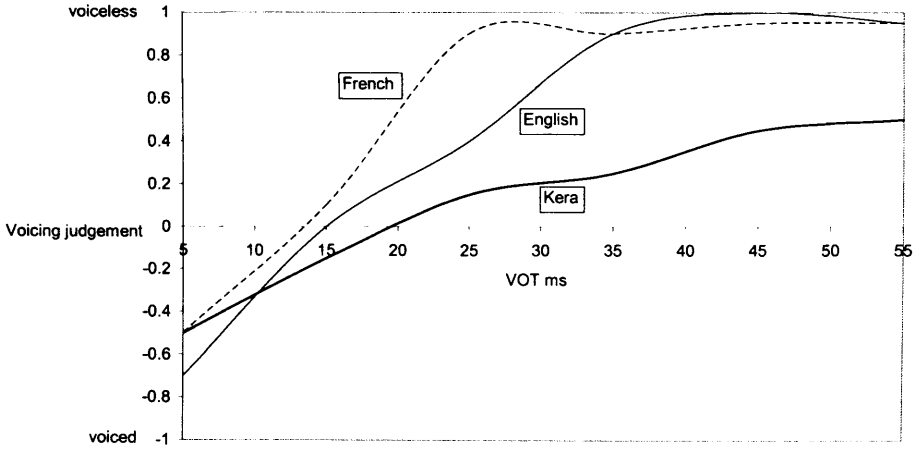
So far we have compared English and Kera. We now include French in the comparison. The following graph shows the results of the F0 comparison for the pi/bi words. Similar results were obtained for the other voicing pairs. The slope for French, like English, is almost zero. This means that the voicing judgement is not greatly affected by F0 whether it has the value of 100 Hz or 150 Hz. In Kera however, the VOT value makes the difference between a strongly 'voiced' response for F0 = 100 Hz and 'voiceless' for F0 = 150 Hz. The English graph from (31) is also included for comparison.

(32) *Comparison of French, English and Kera, F0 use in perception*



In (33), we can see the equivalent graph for VOT. The French results for VOT vary more than anticipated. From our knowledge of French as a language which contrasts negative and positive VOT, I would predict that all of the tokens in the test would be perceived as voiceless. The VOT value at which 'voiced' becomes 'voiceless' is 15 ms for English subjects, and around 13 ms for the French, although I would expect the French results to be around 0 ms. It is possible that the results in this test are skewed because there were no negative VOT tokens. As subjects were expecting voiced tokens, they may have adjusted their judgement slightly. It is clear that the Kera and French speakers use VOT differently in perception. The English graph from (29) is again included for comparison.

(33) *Comparison of French, English and Kera, VOT use in perception*



Our conclusion then is that Kera uses both VOT and F0 in voicing judgements in a very different way from English and French. For Kera subjects, F0 is of major importance whereas VOT is of much less importance.

5.5.3 Perception test results – comparison of Kera populations

5.5.3.1 Effects of location

So far we have compared different languages. We now look at the differences that are internal to Kera. The main differences in the VOT and F0 results come from the location of the subject and where they grew up.

Recall that for these tests, the Kera population has been categorized into groups according to their gender and location. There is a steady migration of Kera from village to town, and so the subjects who were measured included people who had come to town at various ages. In these tests, I will consider the male population to be divided into three groups:

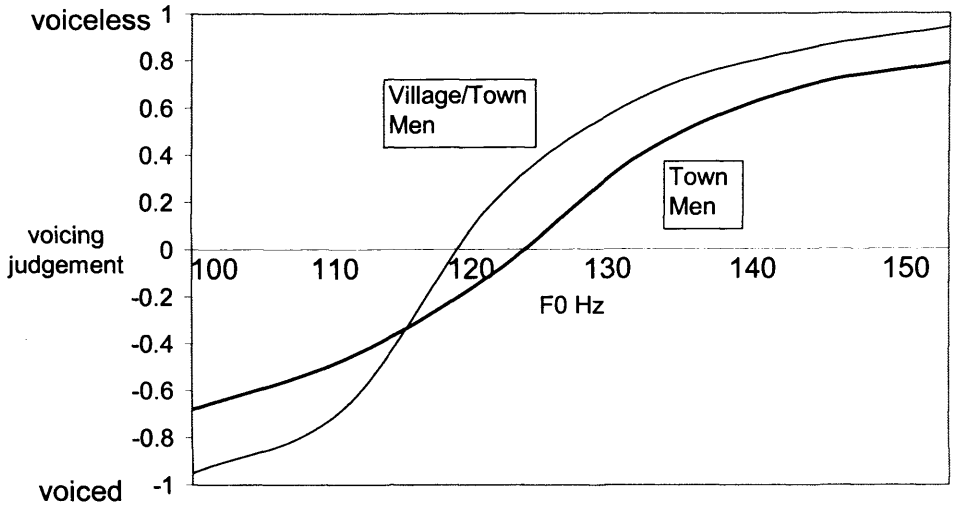
Village Men: Subjects who are still living in a village location
Village/Town Men: Subjects who were brought up in a village, but moved to town after the age of 16
Town Men: Subjects who were born in town or arrived in town before the age of 16.
The women are divided into only two groups as none of the participants in the test fell into the village/town category. So the women's groups are:

Village Women: Subjects who are still living in a village location
Town Women: Subjects who are living in town and who arrived there before the age of 16.

The following tests also refer to 'non-readers'. These are all women, mostly from the village location but also from town.

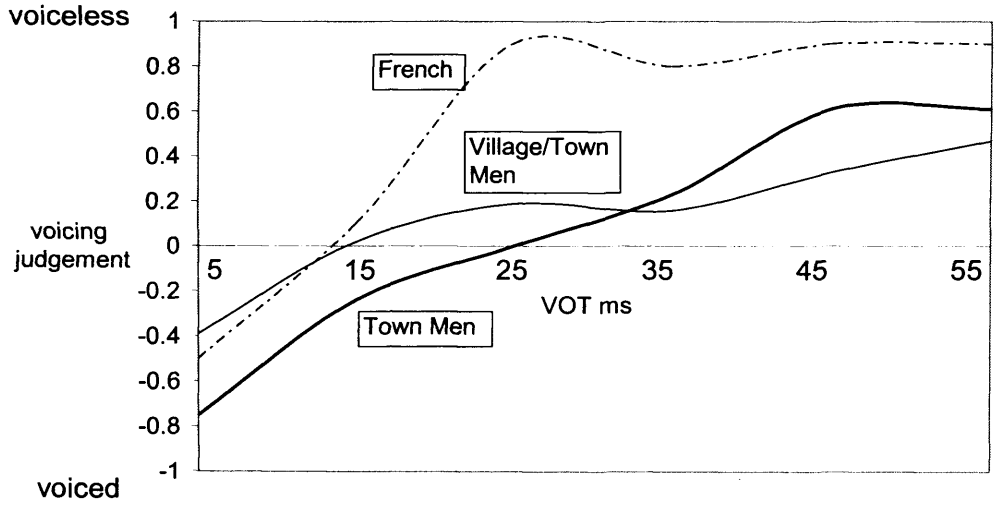
Firstly, we consider the effect of location on F0. (34) compares Town Men to Village/Town Men. We see a significant difference between the two curves. The Town judgement gives a shallow slope. Town Men are using F0 less as a cue than Village/Town Men. For all of them, F0 is still the major cue for contrast, but for Town Men, something is causing the F0 use to be reduced. I claim that the reduction in F0 use coincides with their contact with French. The ANOVA test tells us that the effect of location on the F0 use is significant: $f(3.29, 46.06) = 4.48$, $p<0.001$.

(34) *Comparison of F0 use in perception – Town and Village/Town Men*



Considering the same two groups of Kera speakers, we can see in (35) that the VOT use is also altered. Town men use VOT significantly more than those Village/Town Men. The ANOVA tests confirm that the effect of location on VOT is significant, with $f(3.94, 55.13) = 7.23$, $p<0.001$. The Town slope is more like French.

(35) *Comparison of VOT use in perception – Town and Village/Town Men*

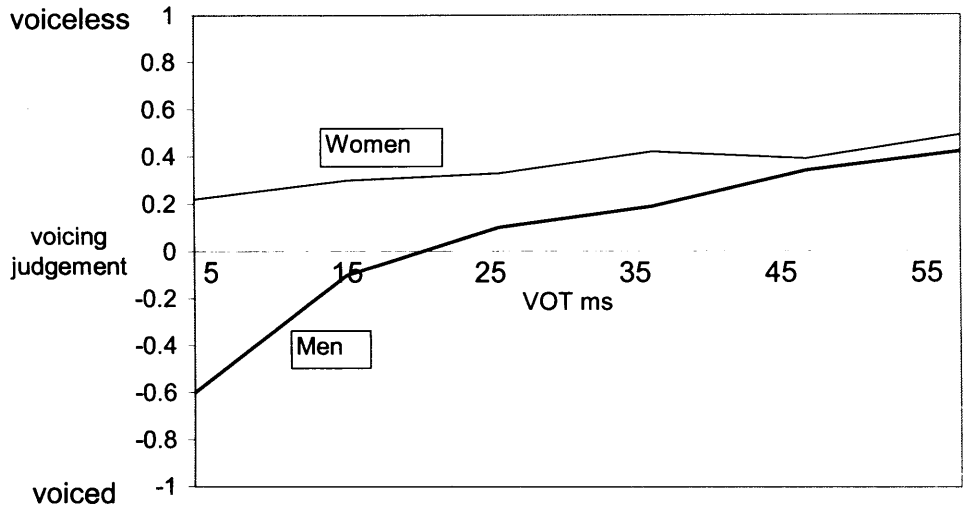


5.5.3.2 Effects of gender

Kera Village and Town Women are less affected by these changes as the following graph comparing men and women shows with the women using significantly less VOT than the men. A possible explanation for this is that women's lifestyles at least in the village involve less of a French environment. Overall, the male and female results look reasonably similar (although the difference is still significant). This may be because the combination of the

female results into one graph masks the variation between Town and Village Women. In the section on production, we will see that women respond very differently depending on whether they are in the village or in town. Their perception is less affected however. This implies that in perception, they have an awareness of how different groups of Kera speak.

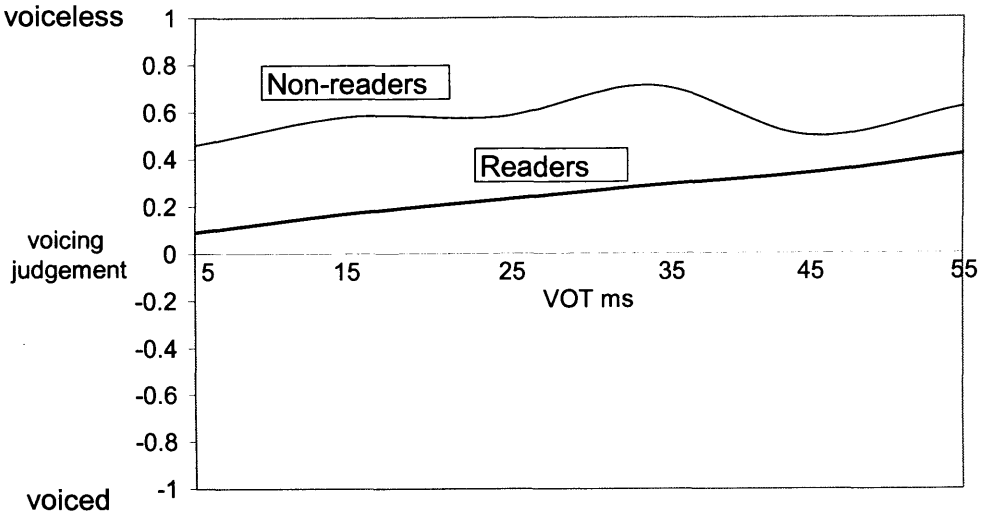
(36) *Comparison of women and men for VOT use in perception*



5.5.3.3 Effects of literacy

In (37), literacy also has a minor significant effect. It is difficult to separate out the effects of the Kera orthography from that of the French orthography. There were not many tested who only read one of the languages. It is also hard to separate out the effects of gender as all non-readers in this test are women. However, the following graph does suggest that at some level, literacy is affecting the use of VOT in Kera perception judgements. Non-readers use very little VOT and readers of French seem to make more use of VOT.

(37) *Comparison of readers and non-readers for VOT use in perception*



The methods of teaching reading in school need to be considered. If they are taught by non-Kera speakers, the children will hear examples in French where the only difference between <k> and <g> is VOT, with little difference in F0. In most village locations, the school teachers do not speak Kera. The child will learn subconsciously that the VOT value is important and the F0 value less important. If the child then sees these same letters used in the Kera orthography, the French patterns may be partially adopted in Kera, especially if the child believes the teacher is better educated and knows more than his mother. The influence of his peers at school will also have an effect.[9]

The role of the Kera orthography for those who don't read French is more difficult to ascertain. The test results are too limited for any confident claim to be made regarding the effect of the Kera orthography, but this would be a promising area of research.

Although the majority of Kera live in a village location, an increasing number are migrating to towns in search of jobs and food. For these people, it is in their interests to master the national language of French. The Kera observe that Kera young men who have been raised in towns are losing their Kera vocabulary. My claim is that their use of phonetic and phonological cues is changing too and this is the reason for the differences in perception for Town Men and Town Women in contrast to the village population.

[9] For non-Kera teachers, the French is likely to be Chadian-French. We cannot assume that Chadian French has all of the same VOT and F0 settings as French from France. However, the main contrast is still in the VOT values rather than tone, so the child will learn that the VOT values are important. Except for the first year of education in a select number of primary schools, the school policy is to teach only in French. See §5.6.4 for more discussion on French as spoken by the Kera.

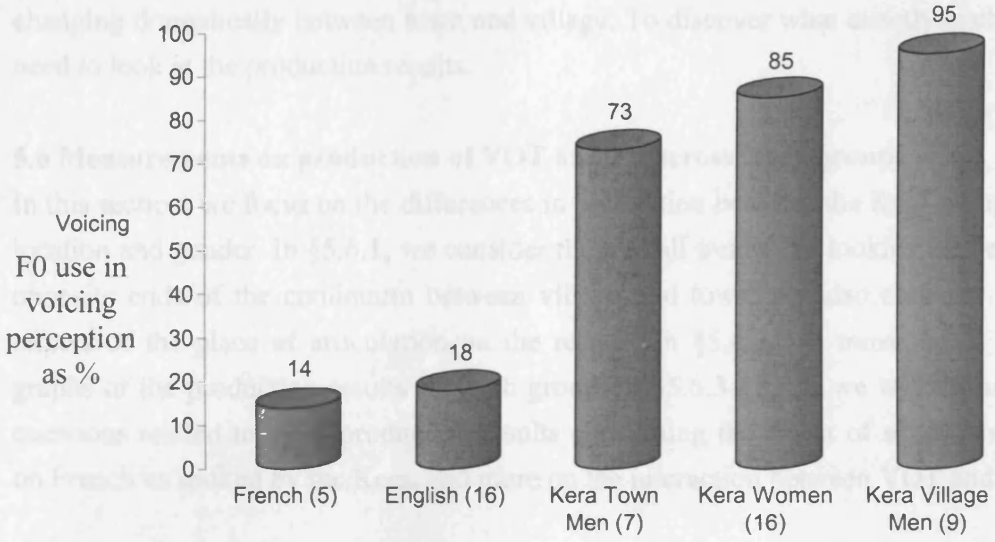
There are two observations from these perception tests that are worthy of further comment. (i) The Town Women use F0 a little more than Town Men and (ii) the Village Women use some VOT as well as F0. Later on when we get to the production results, we will find that both of these are surprising results. The women's perception is more in line with men's perception than we might expect. This could be accounted for by the fact that the voice that everyone heard was of a town male, and it could be that even though it is unlikely that they recognized the voice, they could still be aware of the dialect from other subtle cues and their perception could have taken this into account. Experiments by Strand and Johnson (1996) suggest that subjects take note of extra cues and change their responses accordingly. In their tests, when presented with a male or female photo alongside the same voice, the responses changed. It could be that Kera women take particular note of the male speaker and therefore adjust their responses to his dialect. To test this hypothesis, we would need to repeat the experiment with a female voice. To date, this has not been done. Further research could also consider if Town Women change their perception when they return to their families in a village location. I will discuss Village and Town Women further when we look at the production results.

5.5.3.4 Summary of perception results

I can now summarize the use of F0 and VOT for all of the populations. In (38), F0 use is expressed as a percentage over all of the populations tested using the pi/bi results. In this graph 100% means that there is an F0 value where all judgements (by all subjects) were voiced and there is also an F0 value where all judgements were voiceless. 0% means that the F0 value has no effect on the judgement.

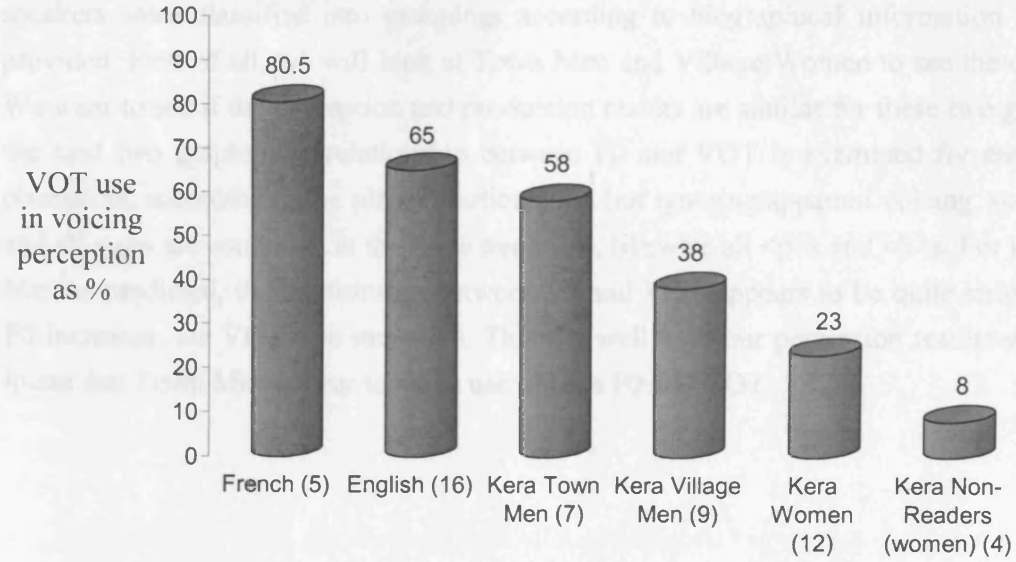
The percentage use was calculated by taking the maximum and minimum voicing judgements for low and high F0. This was then made into a percentage of the total voicing judgement range. This method is helpful for giving an overall picture. The percentages should not be treated as a precise value, more as relative indications of a change in progress. French and English clearly use little F0 while all of the Kera make major use of F0, as I would expect for a tone language where F0 is contrastive. However, Kera Town Men are apparently affected by French, with a slightly reduced (but significantly different) use of F0.

(38) *Range of voicing perception judgements based on changes in F0 (as percentage)*



Turning now to the use of VOT as a percentage, the graph is reversed with French and English using VOT to a great extent (as expected considering that VOT is contrastive). Kera uses less VOT, but there is considerable variation between the Kera populations. Non-readers (all of whom were women) use just 8% while Town Men use 58%. We can assume that the Village Women dialect, as spoken in villages where French does not have a major impact, does not use VOT in perception very much at all. But the French influence is apparent in all the other groups.

(39) *Range of voicing perception judgements based on changes in VOT*



Clearly, Kera VOT use is very different from a non-tonal language like English and it is changing dramatically between town and village. To discover what exactly is changing, we need to look at the production results.

5.6 Measurements on production of VOT and F0 across Kera groups

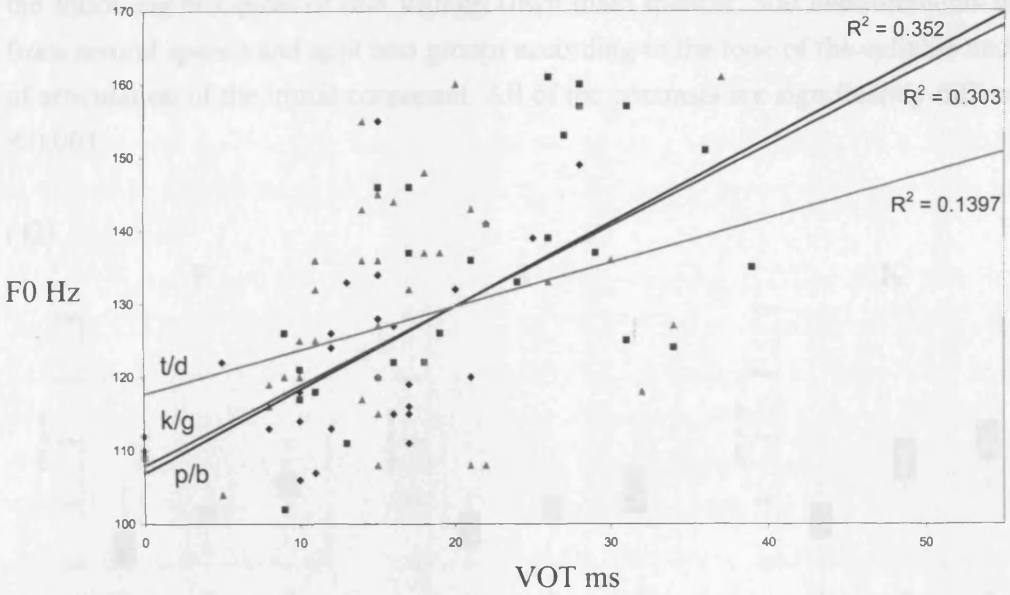
In this section, we focus on the differences in production between the Kera groups based on location and gender. In §5.6.1, we consider the overall trends, by looking at the patterns at opposite ends of the continuum between village and town. we also consider briefly any effects of the place of articulation on the results. In §5.6.2, we move on to normalized graphs of the production results for each group. In §5.6.3-§5.6.5, we will discuss research questions related to these production results concerning the effect of sonorants, the effect on French as spoken by the Kera, and more on the interaction between VOT and tone.

5.6.1 Overall trends in production

A correlation between production and perception cannot be assumed. Bailey and Haggard (1980) found no correlation between average VOTs produced by English speakers in voiced and voiceless consonants and their perceptual category boundary for a /g/-/k/ continuum. Similar mismatches with other consonants and vowels are found by Ainsworth and Paliwal (1984), Frieda et al (2000) and Flege et al (1997). So in this section, we will look at similar groupings to those in the previous section so that we can compare production and perception.

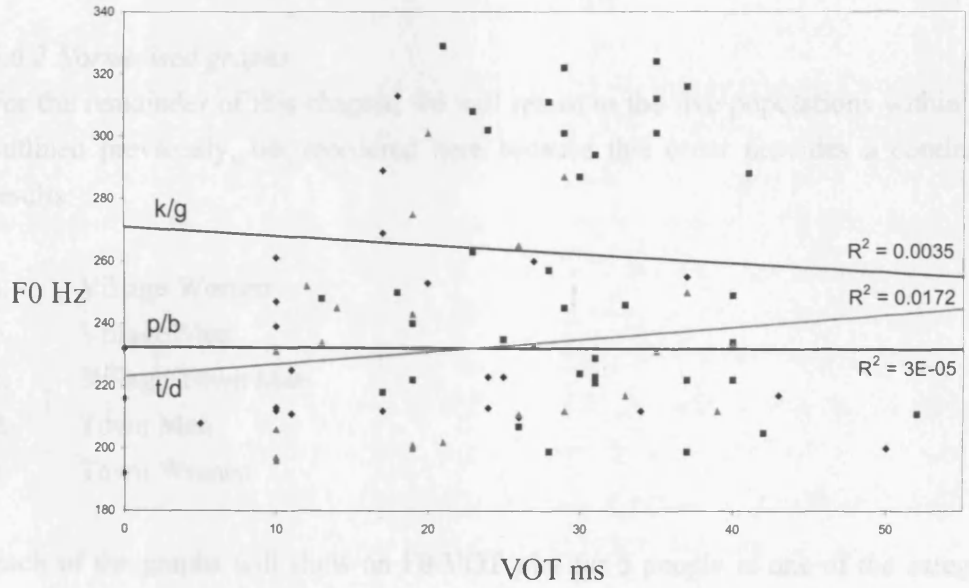
For all of the production measurements that will be referred to here, the data consist of the mean values of VOT and F0 measurements made on tokens from natural speech. The speakers were classified into groupings according to biographical information that they provided. First of all, we will look at Town Men and Village Women to see the extremes. We want to see if the perception and production results are similar for these two groups. In the next two graphs, the relationship between F0 and VOT is examined for each of the obstruents, according to the place of articulation but ignoring apparent voicing, so all <k>s and all <g>s are compared in the same trend line, likewise all <p>s and <b>s. For the Town Men as predicted, the relationship between F0 and VOT appears to be quite strong; when F0 increases, the VOT also increases. This fits well with our perception results where we found that Town Men appear to make use of both F0 and VOT.

(40) *Production of stops from 4 Town Men*



Now considering the Village Women, I would expect VOT use to be minimal based on the perception data, and this is what we find with no upward trend. The trend lines here are not significantly different from each other and are essentially flat.

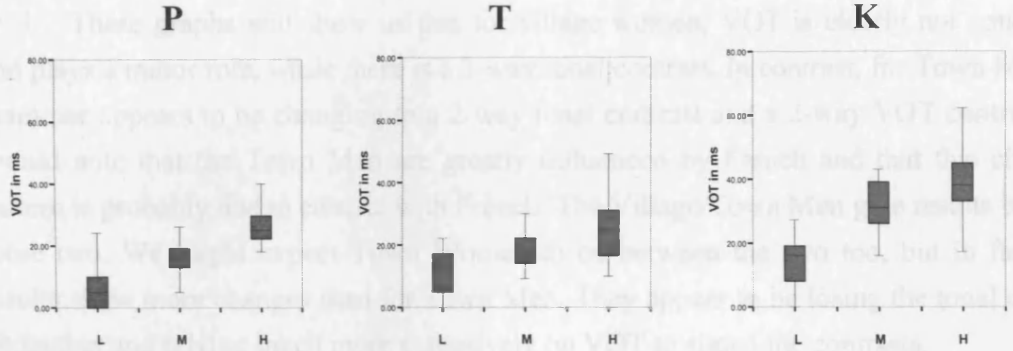
(41) *Production of stops from 4 Village Women*



We are getting a clear picture here that in both production and perception, the F0/VOT relationship is strong for Town Men and almost non-existent for Village Women. In the graphs above, the place of articulation affects the placement of the line, but not

significantly the slope. We can see how the place of articulation affects the VOT length in the following box-plots of one Village/Town male speaker. 300 measurements were taken from natural speech and split into groups according to the tone of the syllable and the place of articulation of the initial consonant. All of the contrasts are significantly different with $p < 0.001$.

(42)



Note that at each place of articulation, the same VOT/F0 connection exists, with the same upwards slope in VOT from L to H. Although there are differences in VOT according to the place of articulation, for the rest of this chapter, I will be combining the results over the three places of articulation so that we can concentrate on the effects of the tonal contrast on the VOT and F0 values.

5.6.2 Normalised graphs

For the remainder of this chapter, we will return to the five populations within the Kera as outlined previously, but reordered here because this order provides a continuum in the results:

a. Village Women
b. Village Men
c. Village/Town Men
d. Town Men
e. Town Women

Each of the graphs will show an F0/VOT plot for 5 people in one of the categories listed above. The points indicate the mean values of L, M, and H. The circles cover the data for each tone in a circle of best fit, estimated by hand. In this chapter we are concerned with the results of the measurements and the changes between groups. We will discuss what grammars are implied by these graphs in chapter 6.

Up to this point, I have used a Hz scale for the F0 values. In the following graphs, a normalized semitone scale is used.[10] This change is due partly to the necessity to normalize the results when comparing five speakers. A semitone scale has been used so that the H tone results are not given more weight than the other tones because of the logarithmic scale. The change in scale may affect the height of the tones in relation to each other, but it does not alter the relationships in any other way. This change makes it easier for us to compare men and women.

These graphs will show us that for village women, VOT is clearly not contrastive and plays a minor role, while there is a 3-way tonal contrast. In contrast, for Town Men, the grammar appears to be changing to a 2-way tonal contrast and a 2-way VOT contrast. We should note that the Town Men are greatly influenced by French and that this changing pattern is probably due to contact with French. The Village/Town Men give results between these two. We might expect Town Women to be between the two too, but in fact their results show more changes than for Town Men. They appear to be losing the tonal contrast altogether and relying much more extensively on VOT to signal the contrasts.

At the beginning of this chapter, we considered how Kera may have developed from having a voicing contrast to having a tonal contrast. These graphs suggest that, synchronically, the process seems to be acting in reverse. A VOT contrast is returning and the tonal contrast is being reduced. This change of direction is caused by French contact. We look first at the Village Women who are not affected by French contact.

a. Village Women

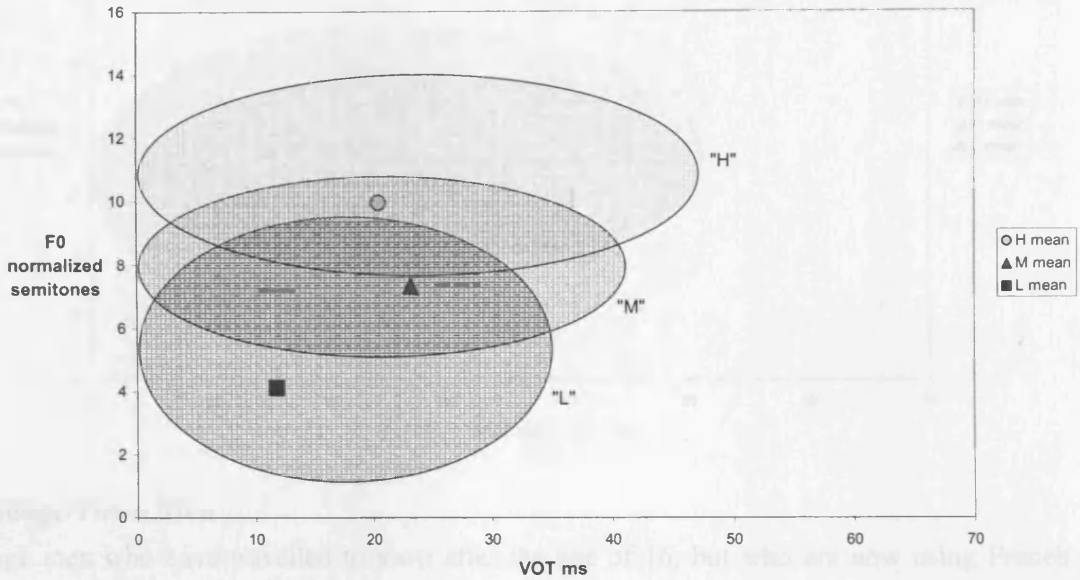
The VOT of word initial stops and the following F0s were measured from natural speech of 5 Kera village women. (43) shows the mean values for the three tones and also the circle of best fit round the whole range of tokens for each tone. The results show a strong tonal contrast of H, M, L, but no VOT contrast, although the range of VOT values (0-50 ms) is large. The L tone range of VOT is smaller (0-35 ms), but the speaker still has freedom within that range. The production and perception experiments both suggest that village women use very little VOT. In phonological terms, VOT has no role to play. It is true that the means for the M and L tones do differ in VOT, but the overall spread of data suggests that this is not being used as a phonological contrast. It was difficult to find women even in a village location who had no contact with anyone speaking French so it could be that the means show a slight effect from French contact. But in any case the main cue to contrast is

[10] Hz values were converted to semitones and normalised using the equation:

Normalized semitones = $12 \log_2 (F0 / F0\ ref)$. To find F0 ref, the mean F0 is calculated for each speaker (Xu forthcoming).

clearly tonal. In all of the graphs that follow, the means do not change very much from graph to graph. It seems that the main change is taking place in the outliers.

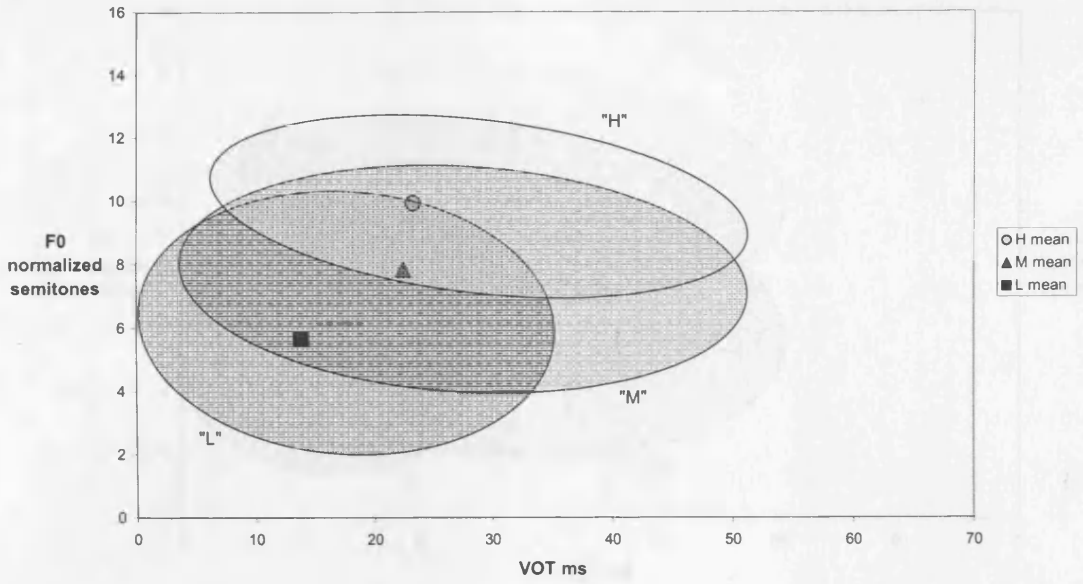
(43) *5 Village Women – VOT and F0 interaction*



b. Village Men

Village men (and some women) are coming into contact with French at school and through literature. French contrasts VOT and not tone. This means that the French contact causes VOT to have more of a role. Consequently VOT plays a minor role in enhancing the major cue of F0 in the contrast, particularly for L tone. By enhancement (Stevens 2003) I mean that minor cues cause the contrast to be more robust while not being the major feature of contrast. (See 5.7.1 for more discussion on this). H and M tone now generally avoid a VOT value of 0 ms and L tone VOT cannot be longer than 35 ms. In (44), we see that for L tone, the F0 range is reduced. The men that were recorded for this production test already had some contact with French and do not therefore represent the most isolated village men. We might expect the most isolated men to have less of a reduction in the VOT range, but data are not available to confirm this.

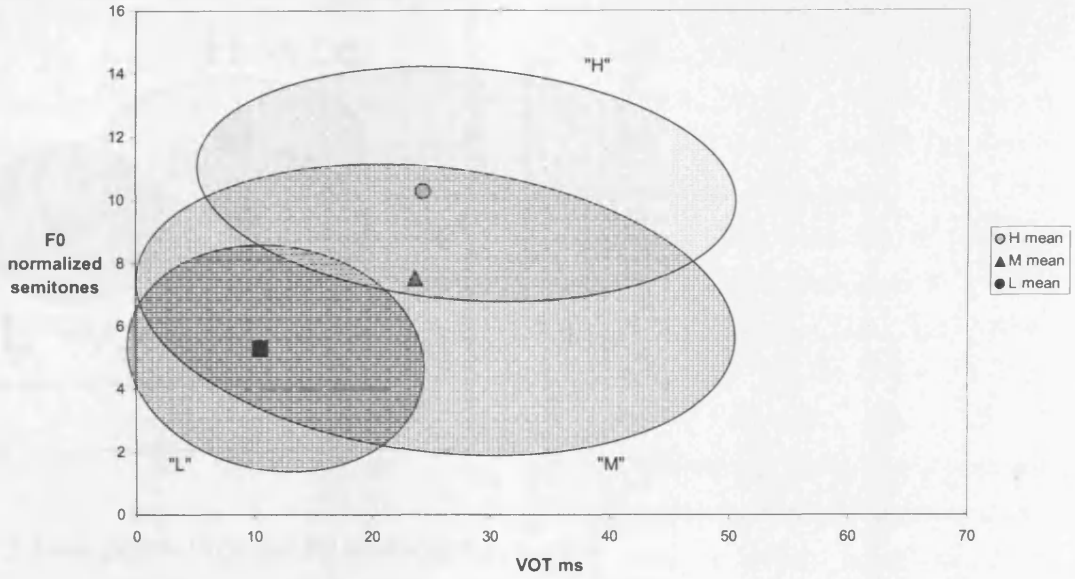
(44) *5 Village Men with some French influence – VOT and F0 interaction*



c. Village/Town Men

Village men who have travelled to town after the age of 16, but who are now using French extensively, show further changes in their use of VOT. This can be seen by comparing (44) with (45). The contact with French is causing an increase in the use of VOT as an enhancing cue. But the F0 3-way contrast is still preserved. The same trends that we saw in Village Men continue with L tone VOT now restricted to 0-25 ms. The L tone appears to be moving into the space occupied by the voiced contrast in French. Observe that the H and M tones remain largely unaffected by French contact. This may be because the tone contrast between H and M is robust enough that it doesn't need changing. Archangeli and Suzuki (1997) have noted that changes usually only occur when there is some reason for doubt or confusion concerning the contrast, with an imperfect transmission from one generation to the next. If there is a change in the Kera M and H tones, it is that the Town Kera have made the contrast even more robust by lowering the M tone slightly to increase the distance from H tone. There is of course no contrast between M and H tone in French. So as there is nothing in French that might be used to replace the contrast, there is no motivation for change.

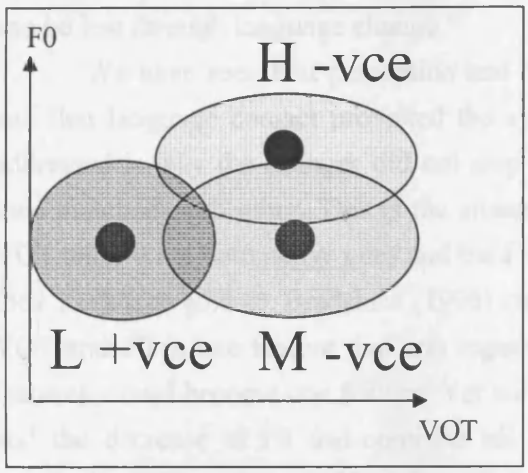
(45) *5 Village/Town Men – VOT and F0 interaction*



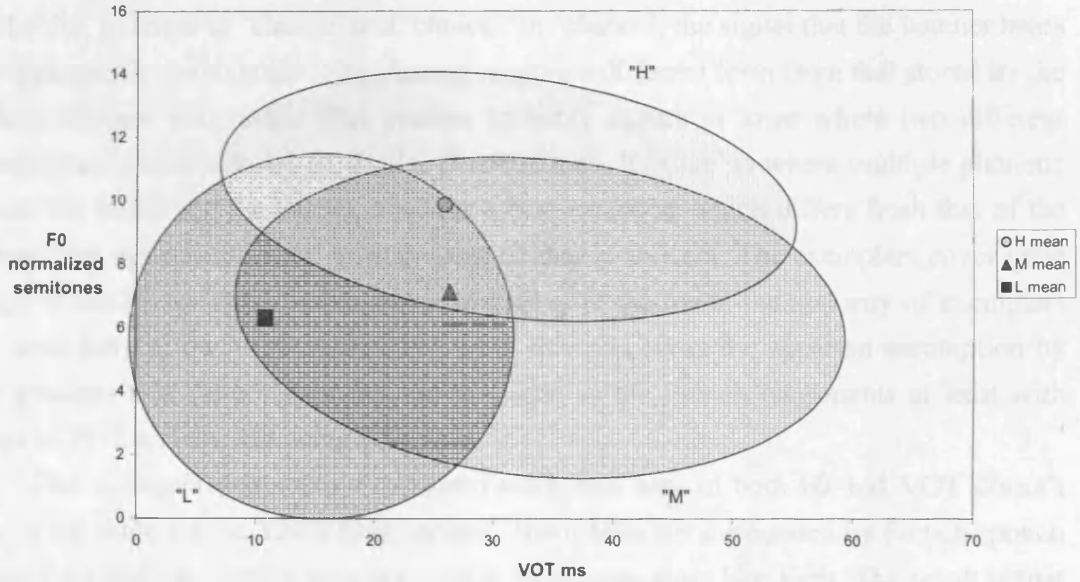
d. Town Men

Kera men who arrived in town before the age of 16 are strongly influenced by French. Some are starting to lose their Kera vocabulary. Many are on the way to reducing their 3-way tonal contrast down to two tones – but with an increased VOT contrast for 'L tone'. The 'L tone' VOT is still restricted to 0-25 ms (and possibly some prevoicing, although generally VOT is still positive), but the F0 value is getting closer to the 'M tone' value. The 'M tone' F0 has more freedom to be lower, while the H tone stays largely the same. The French and Kera orthographies may be playing a role here. In French, <k> means a long VOT, and <g> means short VOT, while in Kera, <k> means H or M tone, while <g> means L tone. If Kera speakers learn to read both languages, this might affect their thinking as to whether these consonants are the same or different. The Kera men appear to be returning to the Proto-Chadic pattern of voicing contrast with an additional binary contrast in tone for voiceless obstruents only. Their grammar is becoming a 2-way contrast of H/L, plus a 2-way contrast [+voice]/[-voice] with a co-occurrence restriction: *[H,+voice]. A schematic version of this is shown in (46), and this can be compared with the empirical results in (47).

(46) *Schematic diagram of Town VOT and F0 interaction*



(47) *5 Town Men – VOT and F0 interaction*



We might wonder what the motivation is for these changes. Halle (1962) and Labov (1972) encourage the view that language change occurs because of languages evolving into an ever more simple state. McMahon (2003) argues that this is not the case. The Kera situation supports her view. Kera has moved from contrasts of 0 tone and 2 VOT, to 3 tones and 0 VOT, to 2 tones and 2 VOT. So in terms of number of contrasts, these changes involve a move from 2 contrasts to 3 contrasts and then 3 contrasts involving 2 dimensions. That is not convincing as a simplification process in any direction. The reversal of any phonological process is rare, but possible, and this fact destroys the argument that all language change involves simplification. Aitchison (2001 p161) notes a case of reversal in Swedish involving devoicing/voicing. Kiparsky (2004) presumably also believes that

reversals are possible as his dictum states that 'Whatever arises through language change can be lost through language change.'

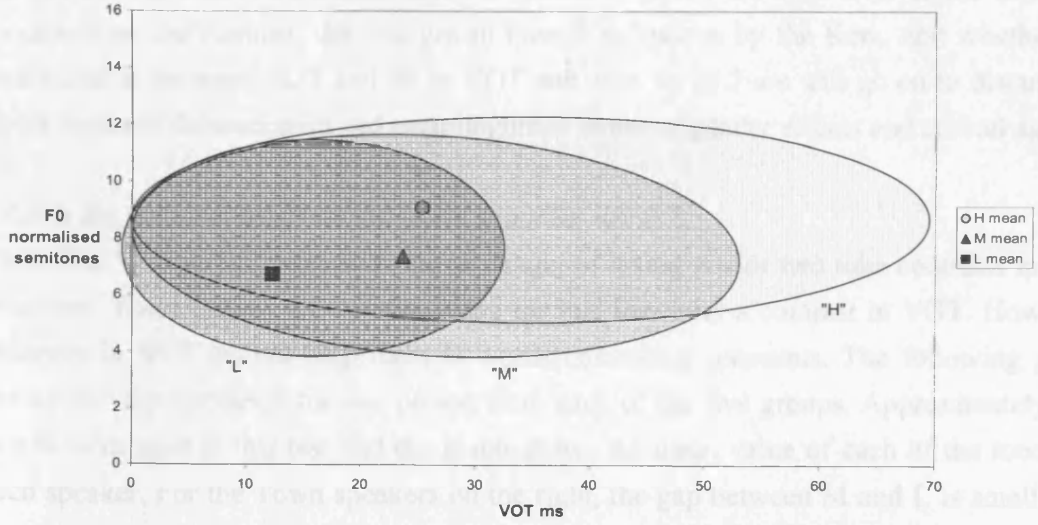
We have seen that perception and tonogenesis motivated the initial Kera changes, and that language contact provoked the synchronic changes, but one question still to be addressed is why the changes did not stop when the VOT and the F0 cues for the Kera L tone matched each other. This is the situation for some Village/Town Men. At this point, VOT and F0 are both active cues and the French consonants of Kera speakers are similar to their Kera (see §5.6.4). Bradshaw (1999) claims that languages have a tendency to combine VOT and F0 in one feature that acts together. We might expect that at this point, the two features would become one feature. Yet we see in Town Men that the increase in VOT use and the decrease in F0 use continue till the F0 difference between M and L tones is practically 0 Hz and the VOT difference is contrastive. It seems that Bradshaw's theories do not particularly apply to Kera. The Town stage implies a further change in the grammar. Blevins (2004, 2006) would probably describe this in terms of evolutionary change, more specifically, in terms of 'chance' and 'choice'. In 'chance', the signal that the listener hears is phonologically ambiguous. If he chooses to store a different form from that stored by the speaker, changes will result. This process probably occurs in town where two different grammars are possible based on similar phonetic data. 'Choice' is where multiple phonetic variants are heard and the listener acquires a best exemplar which differs from that of the speaker. This appears to be the main process of change in Kera. The exemplars cover quite a range in the F0 and VOT space, but as we move to the town, the majority of exemplars for L tone have a low VOT. Also involved in this process is the apparent assumption by Kera speakers that Kera consonants are the same as the French consonants at least with respect to VOT and the following F0 values.

The Village/Town attempt to meet French half way in both F0 and VOT doesn't apply in the same way to Town Kera because Town Men are surrounded by French spoken by non-Kera and that French does not change to become more like Kera. The result is that if the two languages are to have similar VOT and F0 values, the Kera goalposts must move. Town French does not have a strong F0 difference between contrasting obstruents. So the Kera changes to a contrast in VOT and a tonal contrast that is reduced to a difference of two tones.

e. Town Women

Up to now, the perception data largely reflects the production data for the different groupings. But Town Women give different results in the two tests. In perception, they are more conservative than the town men, using the F0 value much more than the VOT value to make the judgement. But in production, they appear to be in danger of losing the tonal contrast. The difference in the two tests could result from the fact that the speaker for the perception tests was male. This would cause them to use the amounts of VOT and F0 that they consider appropriate for a Kera man. This implies that they are aware of other dialects and that they use this information in their perception. The production test on the other hand reflects their own settings for F0 and VOT. For the next graph, only three subjects were measured, but the data was quite extensive. The large circles in (48) could suggest a three-way VOT contrast, but it is unlikely that such a three way voiceless contrast could be maintained. A study of typology shows that there are no known languages with a 3-way positive VOT contrast. Maddieson (1984) notes that a three-way VOT contrast imposes a perceptual burden on listeners and that this is avoided to some extent if one of the series uses voicing or other laryngeal features. Also, we cannot claim a 3-way VOT contrast because there is a large overlap between circles. Any data item with a VOT of 0-30 ms could be in any category. It is more likely that this graph represents the incomplete change towards a two way contrast with the difference between 'H' and 'M' being lost. Up to this point, there has been no loss of contrast as a reduced F0 contrast has been replaced by an increase in the use of VOT, but for the Town Women, there does seem to be the risk of a loss of contrast. It remains to be seen if this will be a loss of contrast across the board or if minimal pairs will retain a difference.

(48) *3 Town Women – VOT and F0 interaction*



These results have implications for anyone who tries to argue from a functional load perspective. In all the other stages, contrast is not lost so each contrast has the same load as before, but it seems that for these women, the loss of contrast is not stopping the changes from taking place. There are parallels in Korean where a loss of contrast between lax and aspirated has meant that in some dialects, there is potential ambiguity between pronouns. However, Silva (2006) argues that the younger generation of Korean speakers are replacing the diminishing lax/aspirated contrast with a tonal contrast. This means that for them, the contrast is not being neutralised. Silva states that for some speakers, the tonal dimension has assumed a primary role in distinguishing lax stops from their aspirated correspondents. So I cannot use Korean as an example of a phonemic merger. This leads us to suppose that the Kera women might also stop short of completely losing the contrast. It is possible that like in Korean, they could find another feature to signal the contrast, such as aspiration. At this point, I cannot predict what will happen, but it is certainly a situation that is worth observing in a few years time. Daniel Silverman (2006, p.c.) is cautious about predictions, but he would expect the contrast to be maintained for minimal pairs with the same part of speech, particularly for *áŋ* 'us' and *àŋ* 'you'. If the women were to lose a tonal contrast, they would probably still be understood. There are only about 20 tone minimal pairs among common nouns, plus some grammatical tone that rarely has to be marked in the orthography because context usually gives enough cues. Of these minimal pairs, the majority are between H and L. There would be a few problems such as *áŋ* / *àŋ*. If there is no tone difference, VOT would not help for these. It is possible that tone would be retained just on these words. In certain dialects of Scandinavian (Bye 2004), tone contrasts are also disappearing, and in these cases too the tones can be retained only for minimal pairs. It would be worth testing the minimal pairs for Town Women.

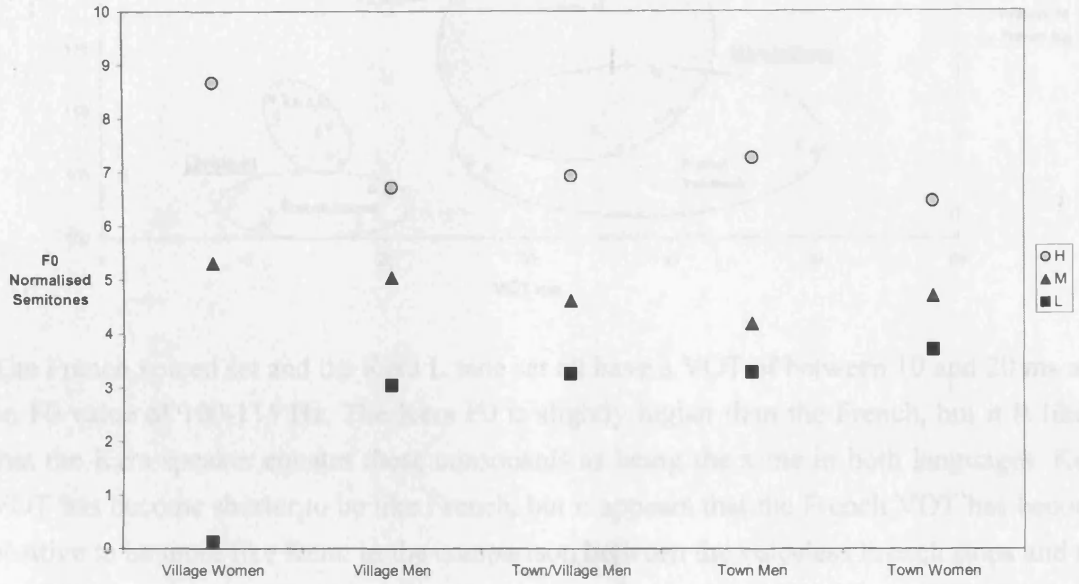
In the remainder of the chapter, we will be discussing research questions related to the production results outlined above. In §5.6.3 – §5.6.5 we will look at the effect of sonorants on the contrast, the changes in French as spoken by the Kera, and whether the interaction is between VOT and F0 or VOT and tone. In §5.7 we will go on to discuss the wider topics of enhancement and sociolinguistic issues of gender effects and critical age.

5.6.3 Is the tonal contrast maintained in sonorant words?

Town and Village/Town speakers are in danger of losing one or two tone contrasts in their grammar. These groups are compensating for this loss with a contrast in VOT. However, contrasts in VOT do not help them in words containing sonorants. The following graph shows the measurements for one person from each of the five groups. Approximately 120 words were used in this test and the graph shows the mean value of each of the tones for each speaker. For the Town speakers on the right, the gap between M and L is small (and

close to the minimum detectable difference), but this is still larger than the mean difference in F0 between M and L in general for these speakers. So we can conclude that while some changes in the gap between M and L are taking place, there seems to be a certain resistance to change in sonorant words, presumably because important information might be lost concerning contrasts.

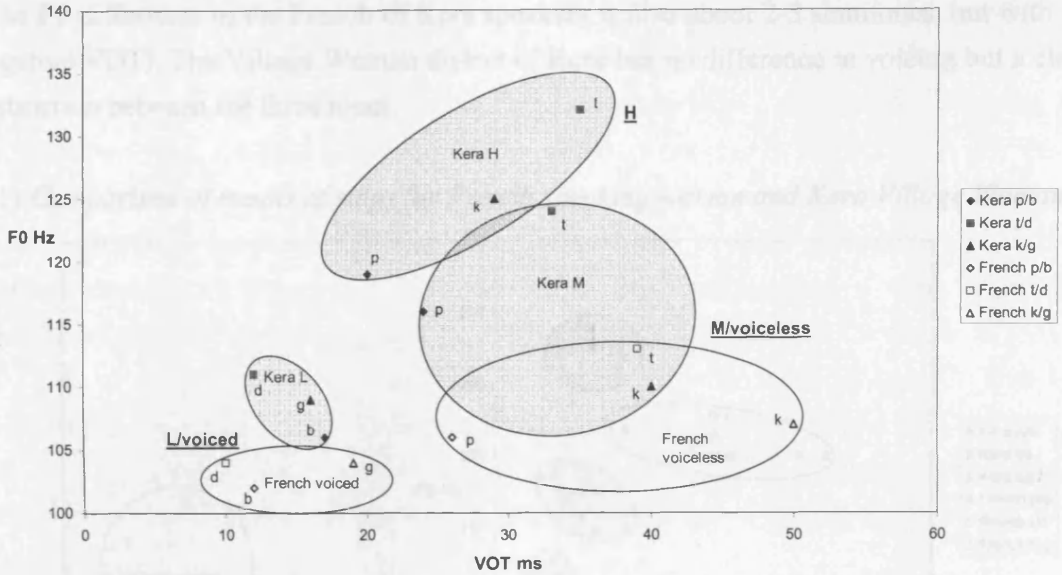
(49) *Tone means on sonorant words*



5.6.4 Is French pronunciation affected in Kera speakers?

We now move on to consider French as spoken by the Kera. It is particularly interesting to note the effect that Kera has on the French as spoken by the Kera. We have already noted that their Kera is changing, but it seems likely that their French is also changing. The graph in (50) compares the Kera and French consonants for one Town speaker. The VOT and corresponding F0 are plotted in each case. In French there are two contrasting stops at each place of articulation. These have been labelled as voiced and voiceless even though the Kera pronunciation has a positive VOT for all of these. In Kera, there are three contrasts for each place of articulation. The circles group those which belong to L tone, M tone and H tone. Note the closeness of the voiced French set to Kera L tone and likewise the voiceless French set to Kera M tone. The H tone set in Kera has no corresponding consonant set in French.

(50) *Comparison of means of stops in French and Kera for Town speaker AS*



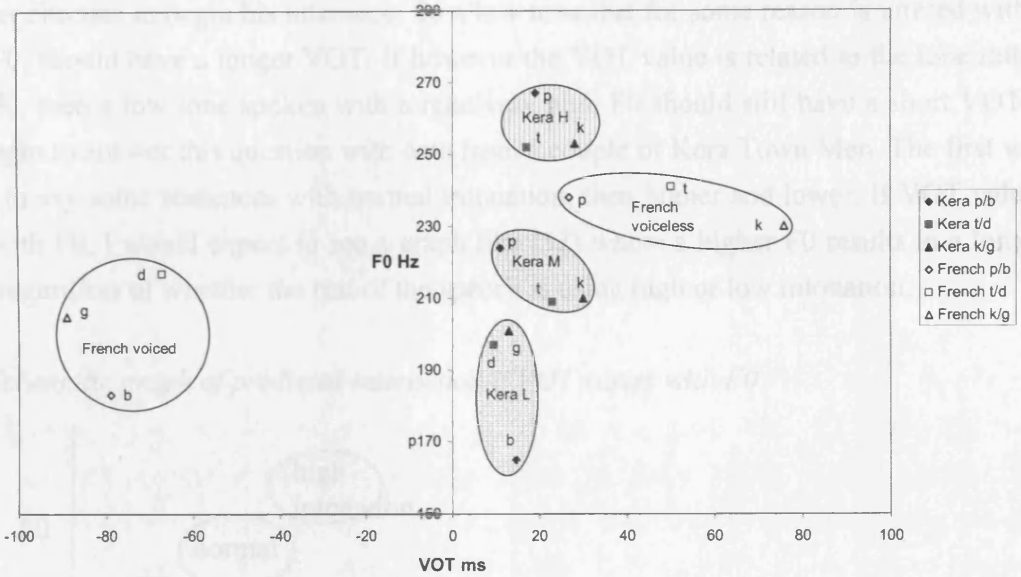
The French voiced set and the Kera L tone set all have a VOT of between 10 and 20 ms and an F0 value of 100-115 Hz. The Kera F0 is slightly higher than the French, but it is likely that the Kera speaker equates these consonants as being the same in both languages. Kera VOT has become shorter to be like French, but it appears that the French VOT has become positive to be more like Kera. In the comparison between the voiceless French stops and the Kera M tone stops, we find a greater difference. It is not clear if the Kera equate these two consonants as being the same. For this male speaker, the Kera H tone stops keep the H tone and presumably French has no effect on them. This tone is only affected in the Town Women dialect where the F0 value is lower, with a possible loss of contrast.

(50) can be compared with (51) where the same measurements have been taken for a Belgian woman[11] and a Kera Village Woman (MAR). These two women show what the graph looks like when there is no contact between the two languages. (Neither of these women has any known influence from the other language.) If our Kera Town speaker was not affected by French contact, I would expect him to produce a similar graph to (51) for his Kera and French. But this is clearly not the case. The French results in (51) show a true

[11] These measurements were taken from a recording of French individual words. The positive and negative VOT values may be a little exaggerated as she was enunciating clearly, but the use of voicing in the contrast is so clear that it is unlikely that a recording of natural speech would give a substantially different result. It should also be noted that this speaker did not make any difference in F0 value between voiced and voiceless words when she was asked to read a list of minimal pairs that differed only in voicing. So this implies that the 3 semitone difference in F0 between words with voiced and voiceless onsets cannot have a major role in discriminating between the two contrasts.

voiced/voiceless contrast with an F0 difference of about 3 semitones between the two sets. (The F0 difference in the French of Kera speakers is also about 2-3 semitones, but with no negative VOT). The Village Woman dialect of Kera has no difference in voicing but a clear distinction between the three tones.

(51) *Comparison of means of stops for French speaking woman and Kera Village Woman*

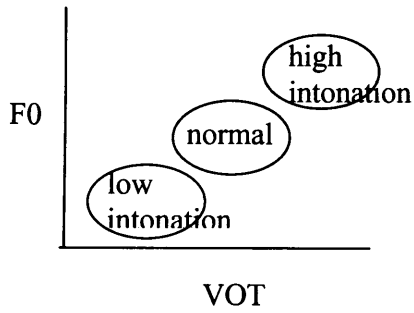


By comparing (50) and (51), we can see that the contact with French has had a clear effect on both languages. It may be that Chadian French has already lost the negative VOT values (and this would be worth measuring), but in any case, it seems clear that the Kera town speaker is equating his Kera L and M tone with the French voiced and voiceless contrasts, and that this is affecting both languages. These data raise some interesting questions about the use of phonetic space by the Kera speaker. We might expect the two languages to be stored separately, but it seems that there is interference, which in turn might imply that they are storing L1 and L2 phonetic data in the same phonetic space. This is a claim made by Flege (1987, 1995) and Best (1995). They suggest that the phonetic categories which are learned in childhood for L1 will evolve over the lifetime of the person as he then learns L2. Bilinguals strive to keep a contrast between the L1 and L2 phonetic categories, but they are stored in the same space. As the speaker gets older, they are less likely to pay attention to the phonetic detail of L2. The interference can be bidirectional as similar sounds in the two languages will either get linked to each other and become more similar, or there will be an effort to keep them apart, so the two languages may both show a move away from the central ground between the two sounds..

5.6.5 Is VOT varying with F0 or tone?

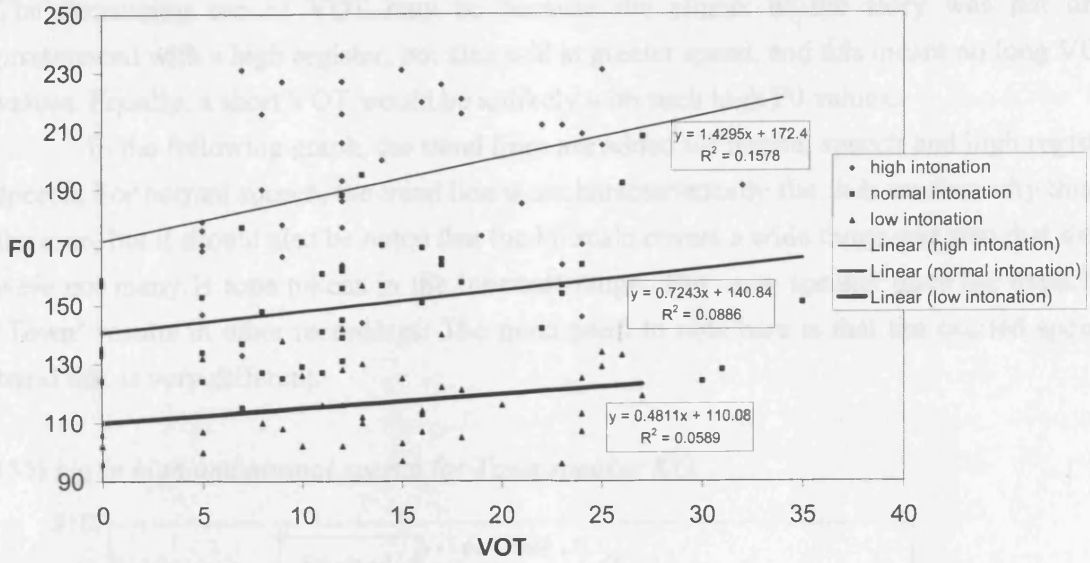
In the discussion of the results so far, the comparison has been made between the VOT and tone rather than between VOT and the F0 value, but I have not yet answered the important research question as to whether the VOT value increases with a higher F0 or whether the VOT increases for a higher phonological tone. If the relationship is directly to F0, then I would expect one trend line over the whole range of sounds, regardless of how high the speaker chooses to begin his utterance. So a low tone that for some reason is uttered with a high F0, should have a longer VOT. If however the VOT value is related to the tone rather than F0, then a low tone spoken with a relatively high F0 should still have a short VOT. I can begin to answer this question with data from a couple of Kera Town Men. The first was asked to say some sentences with normal intonation, then higher and lower. If VOT values vary with F0, I would expect to see a graph like (52) where a higher F0 results in a longer VOT regardless of whether the rest of the speech is using high or low intonation.

(52) *Schematic graph of predicted interaction if VOT varies with F0*



This is not what we get. When the VOT and F0 measurements were taken, it was found that the VOT range was reset for each phrase. So when speaking higher than usual, the VOT value was short for L tones even though the F0 value was higher than some H tones in his normal range. The three trend lines in (53) show the settings for high speech, normal speech and low speech respectively.

(53) *All obstruents in high, normal and low speech for Town speaker DA*



This looks like convincing evidence for a VOT/tone correlation. However, this is not natural speech, and the subject was asked to speak in a high voice. It would be more convincing if I could find evidence that this occurs naturally. When another speaker was asked to say the same sentences quickly and slowly, he raised the F0 values for the fast sentences, and he got a similar result except that the VOT values for L were close together regardless of the F0 value. But this is still not natural speech. The best evidence to date comes from a third informant from the Town Men category who was recorded telling a folk tale. When he arrived at the climax of the story (when we know that the villain is about to fall in a trap which has been prepared for him), the speaker reset the F0 register so that most of the tones appeared to be pronounced with an F0 value almost an octave above their normal value.

In normal speech, this speaker has a distinction between F0 for H and M tones, but his L tone words are distinguished more by VOT than tone. This is typical of Town speakers. But in excited speech, there seems to be more reliance on F0. There are too few tokens to make observations about individual tones, but the system might be something like the following.

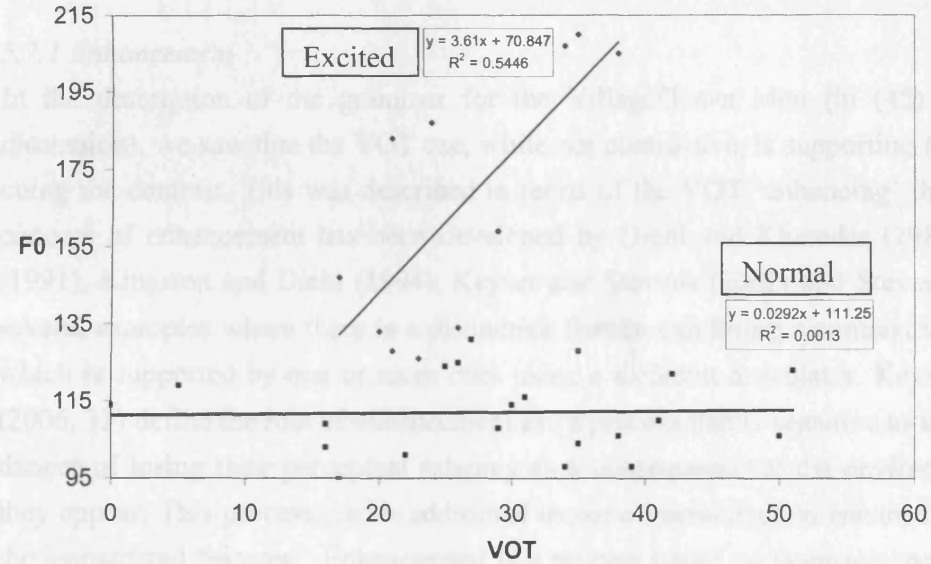
(54) *Tone and VOT interaction for Town speaker KO*

	F0 normal	F0 excited	VOT normal	VOT excited
H tone	110-130	145-215	25-55	15-40
M tone	95-115	125-185	15-50	15-25
L tone	95-120	125-185	0-20	15-25

In excited speech, the VOT value is used less so the F0 value is used more to compensate. The decreasing use of VOT may be because the climax of the story was not only pronounced with a high register, but also said at greater speed, and this meant no long VOT values. Equally, a short VOT would be unlikely with such high F0 values.

In the following graph, the trend lines are added for normal speech and high register speech. For normal speech, the trend line is uncharacteristically flat. It is unclear why this is the case, but it should also be noted that the F0 scale covers a wide range and also that there were not many H tone tokens in the 'normal' range. The same speaker gave the expected 'Town' results in other recordings. The main point to note here is that the excited speech trend line is very different.

(55) *k/g in high and normal speech for Town speaker KO*



From this we can say that the F0/VOT relationship appears to be reset depending on the register and that the way it is reset for excited speech is to increase the F0 range and reduce the VOT range. This implies that the relationship is between VOT and tone. If it were between VOT and F0, I would expect one trend line regardless of the excitement or speed of the utterance.

5.7 Discussion

Certain theoretical issues arise directly from the perception and production tests that we have looked at in this chapter. In this section, we will consider the concept of enhancement in which certain cues, while not being contrastive in themselves, can support the contrast in other features. It is possible that the VOT cues in the speech of Village/Town Men are supporting the tonal contrast in an enhancing relationship. The other main theoretical issue

to be addressed here is that of the sociolinguistic implications of the varying dialects, particularly with regard to gender. It is unusual to see a case where the women are more conservative than the men in one geographical area but more innovative than men in another. It is particularly interesting that the features involved in these two cases are the same, i.e. tone and VOT. Gender differences in one direction are relatively common across the world's languages, so many sociolinguistic claims have been made about the causes of these differences, but the Kera situation can provide a useful contribution to this discussion particularly because the village and town contrast rules out some of the claims. For example if women are just naturally more conservative, the town results are hard to explain and if women are naturally more inclined to experiment verbally, then the village results are hard to explain. We need a theory that can cover both cases. We will discuss this further after taking a look at the question of enhancement.

5.7.1 Enhancement

In the description of the grammar for the Village/Town Men (in (45) and preceding discussion), we saw that the VOT use, while not contrastive, is supporting the F0 values in cuing the contrast. This was described in terms of the VOT 'enhancing' the contrast. The concept of enhancement has been developed by Diehl and Kluender (1989), Diehl et al (1991), Kingston and Diehl (1994), Keyser and Stevens (2001) and Stevens (2003) using several examples where there is a distinctive feature exhibiting a contrast in the language, which is supported by one or more cues using a different articulator. Keyser and Stevens (2006, 33) define the role of enhancement as "a process that is sensitive to those features in danger of losing their perceptual saliency as a consequence of the environment in which they appear. This process...adds additional motoric instructions to enhance the saliency of the jeapardized features...Enhancement is a process based on language-specific properties whose sole purpose is to enhance the output of the universal process at points where the output is perceptually lacking in saliency." So, these cues are not in themselves contrastive, but they aid the perception of the contrast between phonological features. Keyser and Stevens use the example in English (and several other languages) where a non-low back vowel is also rounded. The distinctive feature [+back] is enhanced by rounding because rounding lowers F2 and brings it closer to F1. This causes back vowels to sound more back. They claim that in language acquisition, the contrasts are learnt first, so they suppose that young children would perfect the front/back contrast in the language before the enhancing cues, and that they would not use rounding as a perception cue until later on. Keyser and Stevens have not tested this supposition, but it is claimed that in English (Holt et al 2000, Bernstein 1983), with contrastive VOT which is supported by a change in F0, children tend not to use an F0 cue when making voicing judgements. Bernstein tested children up to the

age of six and found that when they were asked to identify words that varied in word-initial voicing, they did not make use of the fundamental frequency. If true, this suggests that enhancement does not play a major role in acquisition.[12] In the case of English adults, we do know that they make some use of the F0 cue and so this might be considered to be an enhancing gesture.

The participation of F0 in English voicing perception is somewhat limited, as seen in the perception results earlier in this chapter. Among linguists using the term 'enhancement', there are different interpretations of the exact definition. For some, if a cue aids perception, it is considered to enhance. By this definition, the Kera case is a clear case of enhancement, and so is the link between F0 and VOT in English (with the F0 cue enhancing the voicing contrast). On the other hand, some linguists limit the use of enhancement to changes in production that are introduced in order to increase the robustness of the contrast. Under this definition, the F0 perturbation in English might not qualify because its existence in the production data is not under the control of the speaker. The F0 perturbation is simply there as a mechanical fluctuation based on the voicing of the onset consonant and this is in no way controlled by the speaker in order to enhance the voicing contrasts. In Kera, my tests suggest that the VOT value 'enhances' under both definitions. The question would be whether consonants with different F0 values can in articulatory terms be produced with the same VOT lengths. From the Village Women data, I would have to say that the answer is yes because the women do produce all tones with the same VOT.

We can extend this question to consider other languages. We want to know if a co-varying pattern between F0 and VOT is universal. To test this, the minimal pairs in (56) were each recorded twice in Cantonese by one speaker and then measured for VOT and F0. The results are given in (57) in a graph format.

---

[12] These results are questioned by some (Sarah Hawkins p.c.). We know that children pay attention to phonetic detail very early in life, so rather than losing this skill, it could be that they did not perform perfectly in the Bernstein test because they were paying attention to too much phonetic detail and this caused confusion. Lieven (1997), Peters (1997) and Waterson (1971) have shown in studies that children will ignore certain cues, but that is because they are concentrating on some other cue. The salient cues are not the same for all children. Given these results, we cannot come to any firm conclusions on how children deal with enhancing cues.

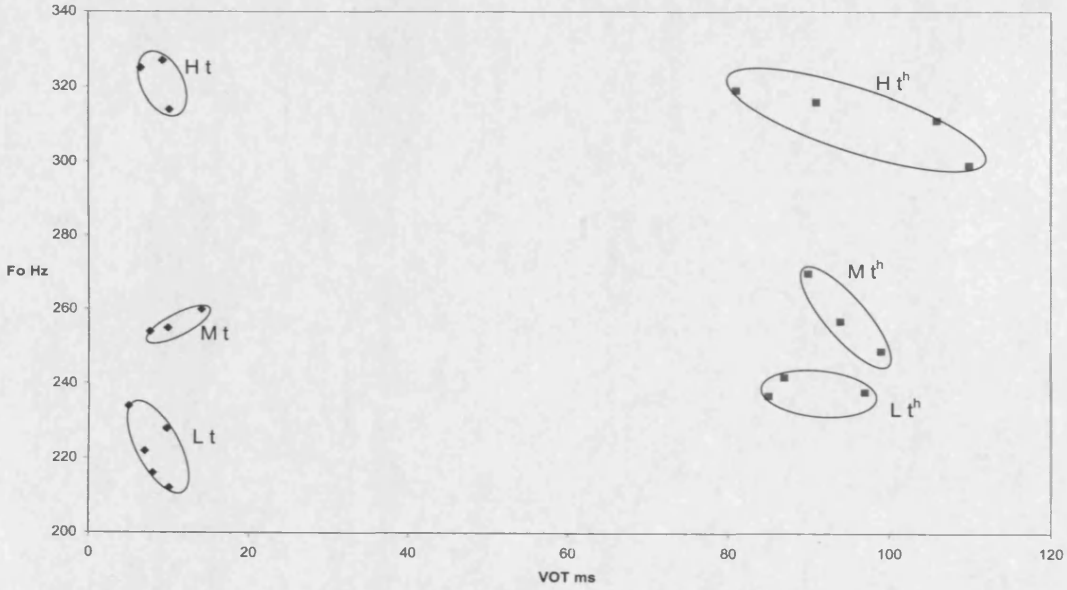
(56) *Cantonese minimal pairs*

Tone (5 is high)

55	dāa	[táa]	'a dozen'
33	daai	[tāai]	'take, bring along'
22	daaih	[tàai]	'big'
55	tāai	[t^háai]	'necktie'
33	taai	[t^hāai]	'too'
55	dāan	[táan]	'bill'
33	daan	[tāan]	'birthday (for deities)'
22	daahn	[tàan]	'but'
55	tāu	[t^háu]	'stealthily'
33	tau	[t^hāu]	'light a fire'

In every case there was a gradual drop of around 20 Hz from the beginning to the end of the vowel. For the unaspirated [t] there was also an initial sudden drop of about 10-20 Hz. This occurred regardless of the following tone. The measurements were taken near the beginning of the vowel but after the drop for [t]. The results in the graph below make it clear that both [t] and [t^h] can occur in the environment of the 3 different tones without any effect on the VOT. For both [t] and [t^h], the three tones are above each other. If the tone had an effect on VOT, we would expect the high tones to have a higher VOT than the low tones.

(57) *Cantonese VOT and F0 values*



In the interests of time, only a few recordings were made, but the results are clear enough for further measurements to be unnecessary. Clearly in Cantonese, the VOT and F0 values are not co-varying and the two systems work independently. Cantonese has contrasting tone and contrasting VOT. Cantonese shows us that the speaker is not obliged to change the VOT as tone changes for any articulatory reason. The F0 value clearly does not automatically dictate the VOT value. We can conclude then that the co-varying patterns found in Kera are not universal and non involuntary, and that the support given by VOT values to the tonal contrast is a good candidate for being considered as an enhancing cue.

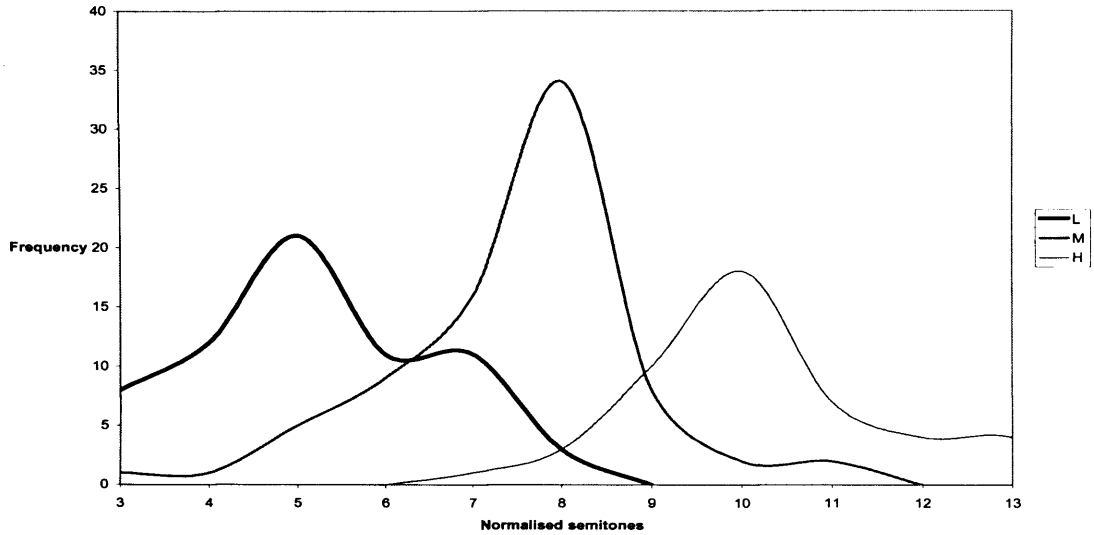
The variation in the interaction between VOT and F0 in different Kera populations supports the claim of enhancement. In Village/Town Men, we have seen that tone is distinctive with a 3-way contrast. VOT on the other hand is not contrastive. But VOT has a clear role to play in the perception of voicing, particularly when the F0 value is in the middle ranges (120-130 Hz). At these values, the tonal category could be in doubt because Kera speakers could produce all three tones with 120-130 Hz. For this reason, secondary cues are important to aid the perception and at this point, the VOT value is an important cue. In contrast to this, when the F0 value is high or low, Kera speakers do not make much use of VOT in voicing perception judgements. This means that if a word like /pi/ [pi:] 'lift' is said with a long VOT and a low F0, the long VOT is ignored and the Kera will perceive it as 'voiced'. However, if the F0 value is in the middle range and the VOT is long, the judgement will change to 'voiceless' because the enhancing VOT cue now has an important role to play. This variation in salience depending on the ambiguity of the main gesture is typical of enhancing cues according to Keyser and Stevens (2001). Enhancement makes a given segment maximally distinct from its nearest competitors, and this is seen most when the information from the distinctive feature alone is ambiguous.

In the cases observed by Keyser and Stevens (p272), they claim that enhancement takes place when a single articulator recruits another articulator to be manipulated together with the first in order to strengthen the relevant acoustic property. The phonological input of the main articulator is 'discrete and quantal', while the enhancement input is 'non-discrete and continuous'. In English, the F0 gesture is clearly not contrastive and the F0 values are on a continuum, so this could be enhancement. In Cantonese, there is no enhancement at all between F0 and VOT and both of these features are contrastive. In Kera, it is the VOT cue that fits the criteria for 'enhancing' as it is non-contrastive and gradient in nature.

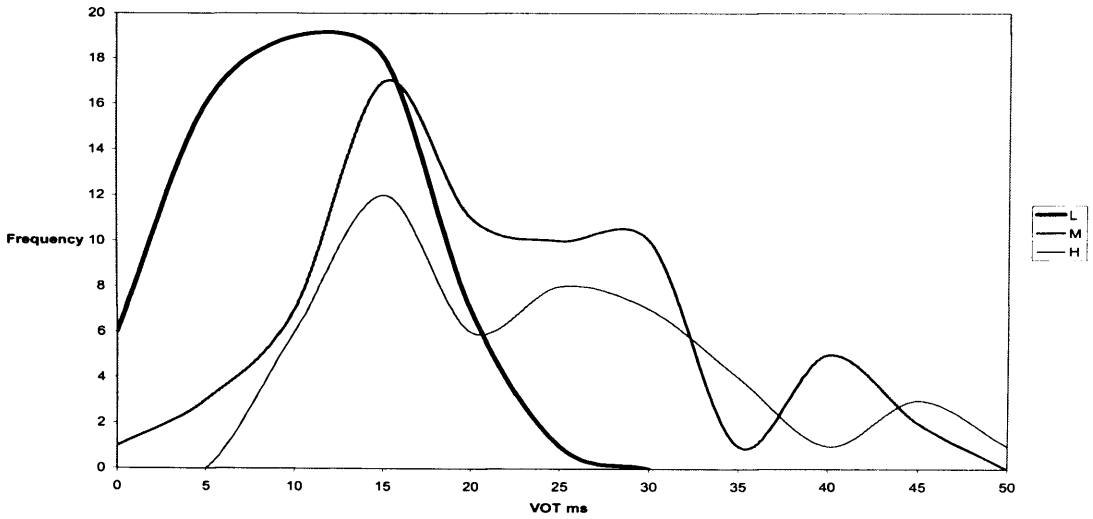
Enhancement in Kera is seen most clearly in the Village/Town Kera where F0 is contrastive and VOT is an enhancing cue. In this dialect we expect to see F0 as categorical and VOT as more gradient. This can be illustrated in the following graphs showing an amalgamation of all the F0 values and VOT values for each tone in the Village/Town data.

By comparing these two we can see that while there is some overlap for F0 between tones, the grouping is much more categorical than for VOT where the top two tones allow any value of VOT. It is true that the VOT for L tone is clearly lower, but there is still a major overlap with the other two tones, and the most frequent VOT value is between 10 and 15 ms for all three tones.

(58) *The categorical spread of F0 values for Village/Town contrasts*



(59) *The gradient spread of VOT values for Village/Town contrasts*



Graph (59) in particular demonstrates that VOT is being used as an enhancing cue only to distinguish L tone from the other tones, so L tone is supported by a short VOT, but a short VOT does not necessarily imply L tone. At this stage in the process of language change, the F0 value is clearly still the principal cue to contrast and often the only one in H/M cases.

The way the enhancement would work is that if the listener hears a long VOT, that must be H or M tone. If he hears a short VOT, that could be any tone, but if it is especially short, it is probably L.

Note that if I tried to argue that voicing is contrastive, plotting 'voiced' and 'voiceless' obstruents, I would get similar graphs but with the thin (H) and medium (M) thickness lines combined into one curve. This would still suggest that the F0 graph has contrasts while the VOT graph has a gradient difference. So I would still conclude that there is a tonal contrast and that the VOT value is of secondary importance.

Keyser and Stevens (2001) claim in the English case that the absence or presence of glottal vibration (voicing) is enhanced by the stiffness or slackness of the vocal folds (F0). The production of an obstruent results in a reduced pressure drop across the glottis. The vocal folds are likely to stop vibrating, but they are less likely to stop if the vocal folds are slackened, and there is a decrease in stiffness, together with a lowering of the larynx. All of these gestures enhance voicing. In Kera, the process seems to be the reverse, where the stiffness of the vocal folds is enhanced by the timing of the onset of glottal vibration. Presumably at some point, Kera behaved like English in that the F0 values enhanced the VOT contrast. However, as the tonal contrast developed, the VOT contrast got less, so that eventually the enhancing cue became contrastive and the distinctive feature was relegated to being an enhancing cue. The relationship between VOT and F0 has remained throughout and is learnt by successive generations of Kera speakers, but the phonological and phonetic roles of F0 and VOT have reversed. The situation in Kera suggests to us that enhancing cues can become contrastive and that distinctive features can be reduced to having an enhancing role. This possible change over time is acknowledged by Keyser and Stevens and they refer to the example of the Great Vowel Shift in English where enhancing cues became contrastive.

Enhancement is the 'fine tuning' of a basic phonological contrast. Keyser and Stevens claim that languages use a minimal number of distinctive features but a large number of enhancing cues in order to make the contrasts more robust. This is in line with the different kinds of descriptions that result when phonologists and phoneticians look at the same language. Phonologists desire to keep the system simple with the minimal number of distinctive features, while phoneticians are inclined to describe the 'fine tuning' with careful attention to detail. To describe Kera fully, it is clear that we need both. A phonological description that ignores VOT does not tell the whole story, and even if the claim is made that VOT and F0 are part of one combined feature, we still miss the variation in the relationship between VOT and F0 over time. On the other hand, a purely phonetic description with a collection of cues that could be of any strength does not tell the whole story either. A phonetic description does not explain the salience of F0 compared with the

secondary nature of VOT. It also does not explain the motivation for change which is affected by the contrastive/non-contrastive status of the two gestures. If we accept that both phonology and phonetics are important in the description, we can explain these changes in terms of the interplay between the goal of having a simple contrastive system, with just one feature in contrast, and the need for a set of enhancing cues to make the perception robust. For Kera, this means that initially, the VOT was contrastive and F0 differences were minimal, but as the perturbations in tone increased, the FO took on more of an enhancing role. This increased still further in order to maximise the perception, till the F0 cues became strong enough to be interpreted as contrastive cues. At this point, the desire for a simple phonological system meant that there was one contrast too many. VOT and F0 were contrasting in the same words. For this reason, the VOT ceased to be contrastive. It remained however as an enhancing cue as this helps with the perception. Then with the contact with French, the roles reversed again, and VOT and F0 are now reverting to their original roles. Not many examples of such changes in contrast over time have been cited in the literature. This makes Kera important in our understanding of contrast, enhancement and language change.

5.7.2 What difference does gender make?

The results that we have looked at suggest that in the village the women are more conservative than men, and in town they are less conservative. Both of these situations can be explained in terms of sociolinguistic principles, and there are many examples available of other similar situations, but the author is not aware of any sociolinguistic study which has found gender differences in both directions simultaneously. This example therefore provides an important contribution to the sociolinguistic discussion on gender influence in language change. The Kera example is also important because most gender studies have been conducted on populations within urban situations in the United States; very few rural African situations have been described in the literature.

The Kera production results for Town Men and Women (see §5.6.2) suggest that at the moment, the grammar is the same for both groups, with a two way tonal contrast and another low contrast with short VOT. However, the women's graph has the F0 values closer together and the implication is that all tones are being lost. This means that town women are changing faster than town men in production, even though they still rely more on F0 in perception. Comparing this with village men and women, we see that village women are more conservative than the men, using almost exclusively F0 in production and perception.

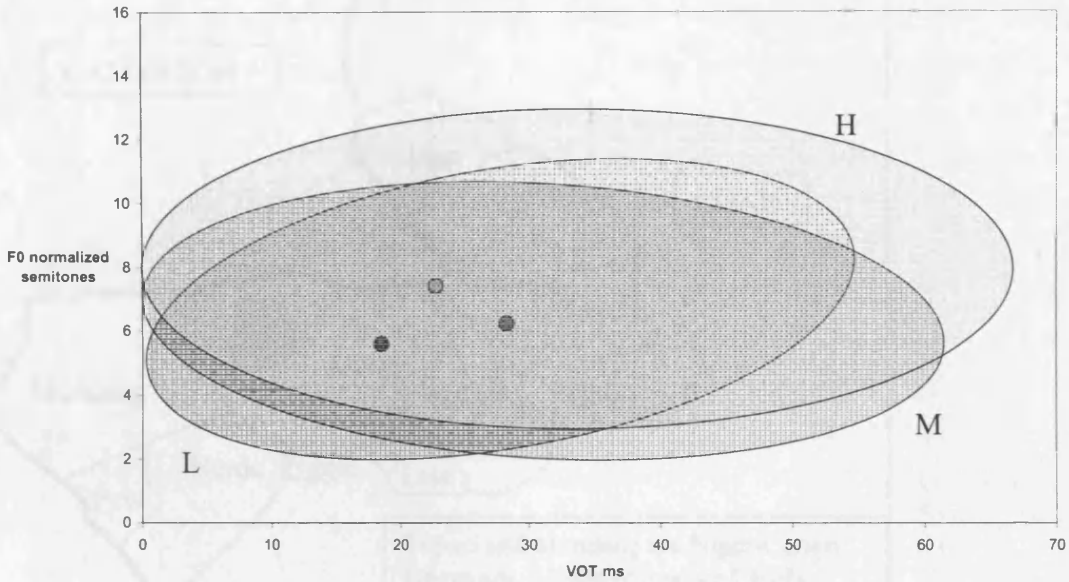
Trudgill (1983) and Labov (1990, 2001) claim that women are more susceptible than men to the language of prestige. In a monolingual stable situation, they will speak

more carefully and conservatively, using the standard forms and favouring the language of high prestige. For example, in English, women are more likely than men to pronounce the interdentals /θ, ð/ in a way that is considered to be 'correct', rather than using the non-standard affricate and stop forms (Labov 2001). But in a situation where there is contact with other dialects or languages, the women in the community who are non-conformists may be the first to change. Wolfram and Schilling-Estes (1998) comment on this: "Women appear to be more conservative than men, in that they use more standard variants...At the same time, women appear to be more progressive than men, because they adopt new variants more quickly." Similar claims are made by Wolfram (1969), Labov (1972, 1990), Trudgill (1983), Haeri (1987, 1996) and Chambers (2003). If their claims are correct, the conservativeness of village women comes from seeing the traditional 3-tone Kera as more prestigious. This is how the elders (male and female) speak. However, in town the French influence encourages the loss of tone and reintroduction of VOT differences. The prestigious language is French, so the women are quick to change their language in the direction of French. As Labov finds in a survey of several languages, the town women who are leading the language change are around 20 years of age and upwardly mobile. In the case of Kera, 'upwardly mobile' means that they are getting secondary education and are married to town men. Labov does not claim that all of the town women change uniformly, but those who are non-conformists and who are leading the upwardly mobile group also lead the language change.

It should be noted that the prestige explanation is not the only one offered to explain these results. In the case of the Village women, it could be quite simply a lack of contact with French. Cheshire (2002) suggests other possible causes of the gender difference. These include: women attempting to increase their voice in society by using more standard forms, women wanting to appear less promiscuous, women wishing to be polite and save face, women trying to acquire social status through speech rather than occupation, men identifying with the working-class roughness and masculinity by speaking roughly, and women having a neurological verbal advantage over men. Cheshire believes that all of these might play a role, but she thinks that the main relevant underlying sociolinguistic factor is the relative access to power among men and women. Woods (1997) suggests that women are more cooperative and listener orientated than men so they are more likely to accommodate to speakers of other dialects. Most of these suggestions have the problem that they cannot explain the results going in opposite directions for the Village and Town Women. Only the prestige argument really attempts to do that. It could be that prestige is the main motivation and then the other factors support the changes to a lesser degree. Further testing for the prestige theory could be done. The results of the Village/Town Women would be crucial. We would predict a sudden change as French becomes

prestigious to the Women, so probably most Village/Town Women would have a grammar somewhat like Town Men. It has not been possible to measure the VOT and F0 values for a number of Village/Town women, but the results for one are shown in (60), based on 140 data points.

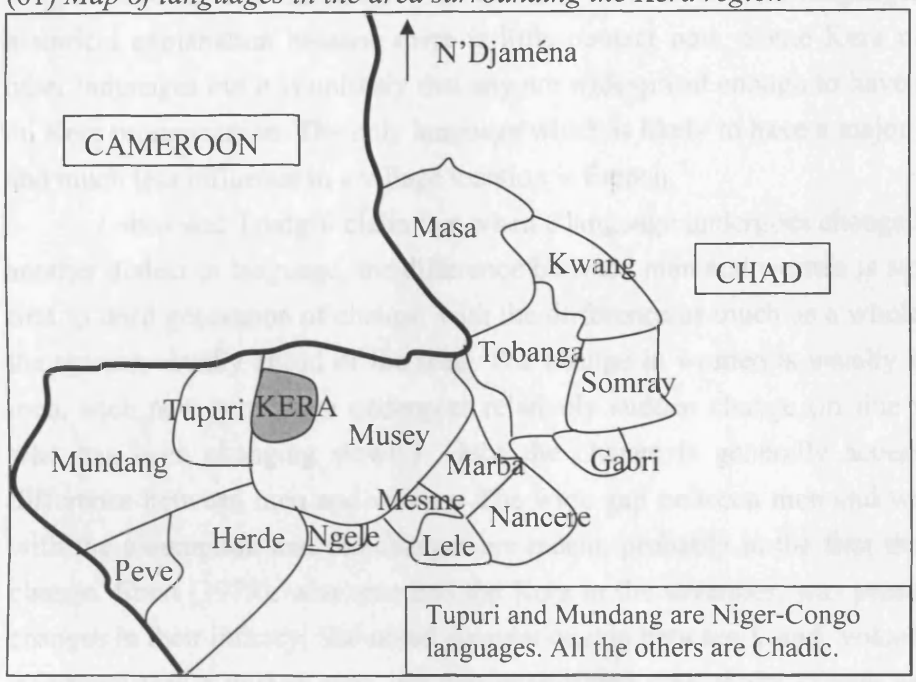
(60) *Plot of VOT and F0 for Village/Town woman*



We can see that these results resemble the Town Women results except that there is slightly more division on the F0 scale and less division on the VOT scale. As with the Town Women, there must be some confusion in the contrasts. Much of the phonetic space is occupied by all three contrasts. This woman was brought up in a small town around the Kera area, so she may have been influenced by French to some extent, but she was probably also influenced by the neighbouring language Tupuri (with 4 tones and a voicing contrast) which is spoken in the town where she was brought up as well as Kera. She moved to the city to get married, presumably when aged around 16. She is now aged around 37. She generally stays home with her seven children, but she also sells at market. This means that she probably has relatively little contact with French. This could explain the lack of distinction in VOT, but she has clearly lost some of the tonal contrast too. Given this loss of contrast, we might expect her to have more contrast for minimal pairs, but the recording I have suggests that this is not the case. For example the phrase *pépéŋ kēy áré:* 'God helps us' was pronounced as [pēbēŋ gèy áré:] which could be understood as 'God tires us'. Presumably the context makes the meaning clear. Although I can't claim too much based on one person, it does seem that Village/Town Women, like Town Women, are showing progressive patterns and are in danger of losing contrasts.

In this thesis, I have only looked at the influence of French, which we know has a voicing contrast and no tone. There are of course other languages that could potentially influence the Kera as the map below shows.

(61) *Map of languages in the area surrounding the Kera region*



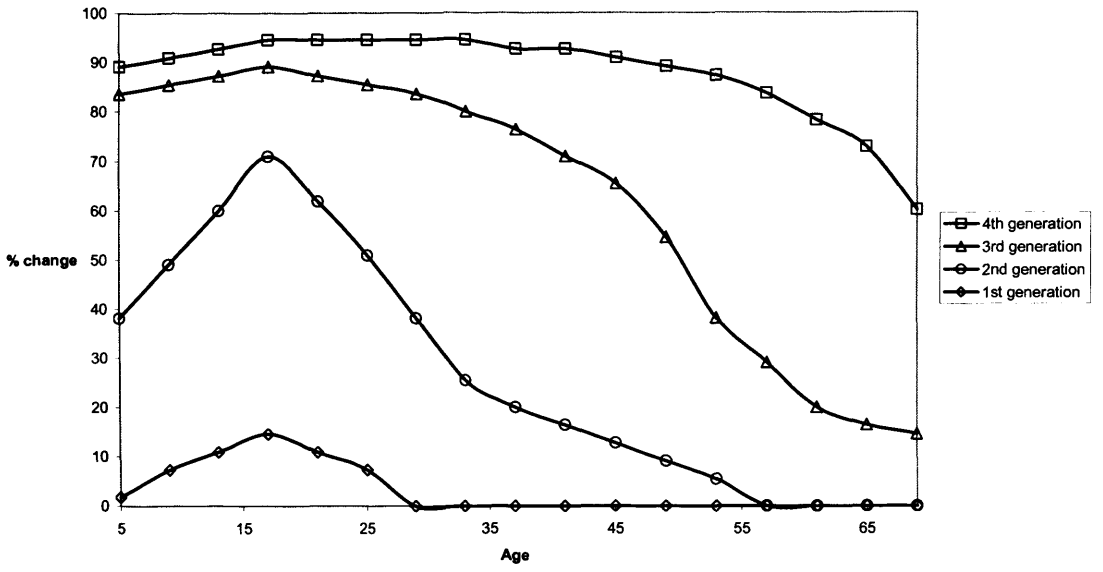
The closest language is Tupuri which is a Niger Congo language. It is reported to have 4 tones and voicing. A number of Kera speak Tupuri and certain words have entered Kera as loans. These words have tones that are unusual for Kera and other phonetic sounds such as nasalized vowels, but there is no argument for saying that Tupuri is causing the changes described in this chapter. Firstly there is no clear reason why Tupuri might motivate the shortening of VOT for the L tone and secondly the contact with Tupuri is much the same in all geographical locations. It is true that the Kera feel the dominance of the Tupuri group and have adopted many of their customs, sometimes calling themselves Tupuri when they travel, but there is probably less contact for the Kera with the Tupuri in the capital and there is a resistance to using Tupuri for more than market transactions. Some of the Kera women are likely to be influenced by the neighbouring Chadic languages Musey, Marba, Mundang and Masa. Some of the wives chosen by Kera men speak Musey as their first language. This is not the case for any of the women recorded for the tests in this thesis, but it is true for some of their friends. However, these languages are unlikely to have an effect on Kera. In terms of location, they are unlikely to affect town speakers without also affecting village speakers. The area where Kera and these other languages are spoken is about 200 miles from the capital (with travel by minibus once a week in dry season) so it is unlikely that

they could affect town speakers. We also know from the studies on Masa and Musey that the VOT and F0 cues are not particularly strong, so they are unlikely to affect a neighbouring language. Studies in lexicography suggest that Kwang is the nearest language linguistically with 42% cognates (Gordon 2006), but geographically it is too far from the Kera to have any real influence. The similarity between the two languages must have some historical explanation because there is little contact now. Some Kera men speak several other languages but it is unlikely that any are widespread enough to have a major influence on Kera pronunciation. The only language which is likely to have a major influence in town and much less influence in a village location is French.

Labov and Trudgill claim that when a language undergoes change from contact with another dialect or language, the difference between men and women is strongest during the first to third generation of change, with the difference as much as a whole generation, with the women usually ahead of the men. The change in women is usually gradual, while for men, each new generation undergoes relatively sudden change (in line with their mother who has been changing slowly). Once the change is generally accepted, there is less difference between men and women. The wide gap between men and women in Kera fits with the assumption that the changes are recent, probably in the first three generations of change. Ebert (1979), who recorded the Kera in the seventies, was presumably seeing the changes in their infancy. She noted the relationship between L and 'voiced' stops. Her main informant was a village man, but presumably one who spoke French well. This suggests that we could now be in the third generation.

Labov (2001) gives a model for urban language change split according to gender, and covering 4 generations of change:

(62) *Age profiles for females of a linguistic change in progress with logistic incrementation of the change (Based on Labov 2001)*



Labov's model is based on a generation being fixed at 28 years and a critical age set at 17. To generate the graphs, the assumption is made that acquisition of a different dialect will begin at 5 and then continue till the age of 17. After one generation, the change in dialect of the mother becomes the starting point for the child. The incrementation of acquisition is based on an S curve so that early stages of change happen slowly, but then the rate increases until the change is nearing completion, at which point the rate slows down again. The graphs combine all of these aspects together. The difference between male and female speakers is based on the observation that male speakers are less inclined to adopt any changes, so the model assumes that they retain the dialect of their mother. More details on this model are given in Labov (2001).

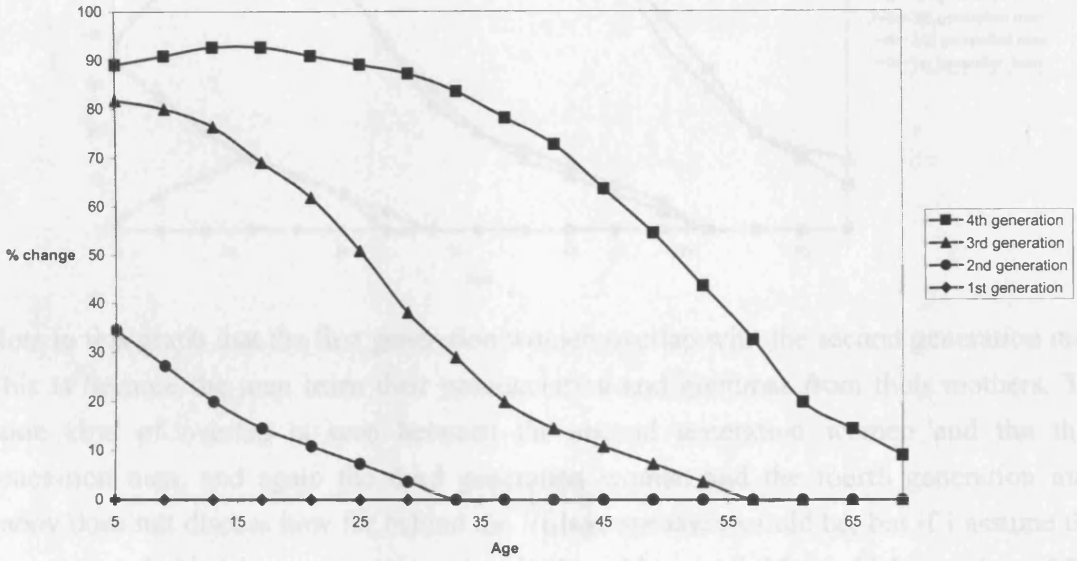
I will attempt to apply this model to the Kera situation. There are plenty of unknowns, including the rate of change in Kera and the final state of the change, but this model can still give us insights as to what is occurring in Kera.

It is hard to judge how many generations of change have occurred among the Kera. The French arrived in Chad towards the end of the nineteenth century and independence occurred in 1960, but we need to know when the Kera started moving to town and coming into contact with the French and the French language. There are certainly some Kera (mainly men) who would have had contact with the French in the 1950s. But most of the migration to town probably occurred after Independence. So for the purposes of this thesis, I am going to make a rough estimate that the Kera have undergone around 3 generations of change. If this is true, the graph in (61) shows us that a 20 year old Town Women would have undergone around 90% of the total change that we expect to occur.

20 is the average age of the town women that were recorded for this thesis, so if this graph is correct, we can suppose that the Town Women results that we have represent the stage where the change is around 90% complete.

Now consider the pattern for men. (62) gives the graph for language change in the male population.

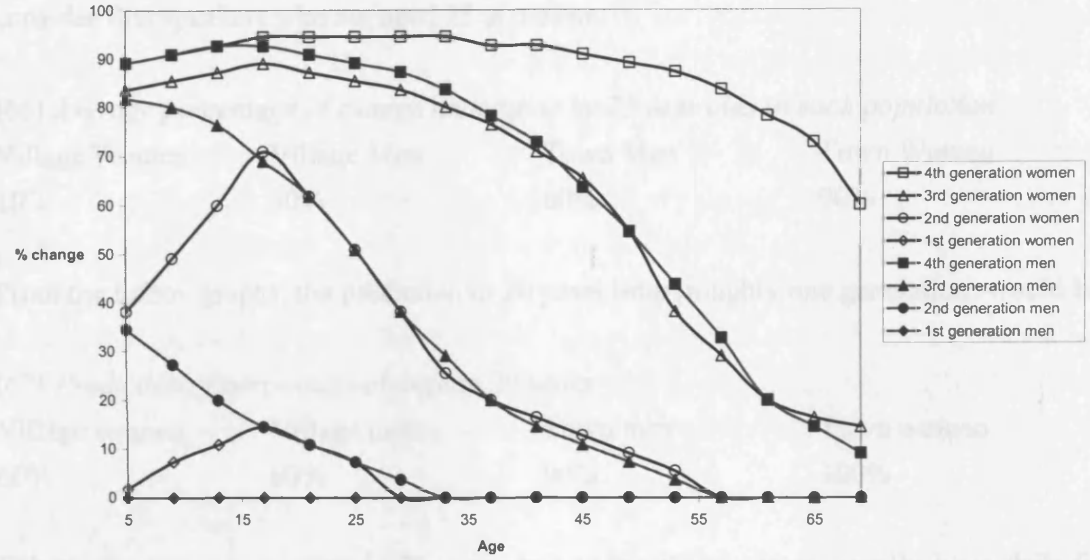
(63) *Age profiles for males of a linguistic change in progress with logistic incrementation of the change (Based on Labov 2001)*



If we again assume that the Kera have undergone 3 generations of change, then Town Men aged 25 would have undergone around 60% of the total change. 25 is the average age of the town men recorded. The assumption that the Kera have undergone 3 generations of change is confirmed by the fact that Town Women and Town Men still have differing production results. If 4 or more generations of change had taken place, we would expect the male and female results to be more similar to each other as Labov (2001) notes that when the change nears completion, the differences between males and females seems to disappear. At 3 generations of change the differences between groups would be large, and that is what we have observed.

Superimposing these two graphs, we get the following graph.

(64) *Age profiles of a linguistic change in progress with logistic incrementation of the change (Based on Labov 2001)*



Note in this graph that the first generation women overlap with the second generation men. This is because the men learn their pronunciation and grammar from their mothers. The same kind of overlap is seen between the second generation women and the third generation men, and again the third generation women and the fourth generation men. Labov does not discuss how far behind the Village speakers would be, but if I assume that the men are behind by a generation, then Village Men aged 25 would be at about 30%. Village Women are more conservative, so if I estimate that they are about two generations behind and aged 25, their change is 10% or less. These figures are of necessity very approximate (being based on the assumptions that the Labov graphs can describe the Kera data, that the Kera change has occurred for three generations and that the village is 1 or 2 generations behind the town), but they do seem to fit with the Kera production results presented in this paper providing we try the working hypothesis that change takes place in the following equal steps:

(65) *VOT/tone relationship at various stages in the process of change*

0% change: 3 tones and no VOT contrast

25% change: 3 tones and an obvious relationship between L tone and short VOT

50% change: 3 tones, but L tone cued more by VOT than by lower F0

75% change: 2 tones with VOT difference for old L tone

100% change: 2-way contrast with VOT difference, no tone

These percentages have to be treated tentatively, as they are based on a number of assumptions, but if we suppose that they are correct, then we can use Labov's graphs to find out how much of the change the average Kera speaker will have undergone. We consider first speakers who are aged 25 at present:

(66) *Average percentage of change undergone by 25 year olds in each population*

Village Women	Village Men	Town Men	Town Women
10%	30%	60%	90%

From the Labov graphs, the prediction in 20 years time (roughly one generation) would be:

(67) *Prediction of percentage change in 20 years*

Village women	Village men	Town men	Town women
60%	80%	90%	100%

Labov assumes a generation is 28 years, but as the Kera women usually have their first child at 16-18, I am assuming that a generation is more like 15-20 years.[13]

The prediction for Village Women in 20 years assumes that they take their prestigious forms of Kera from the male elders in society. But if they do follow the patterns of the older women, then they may change very little, and the village men might then follow them. This would give two dialects (Village and Town).

(68) *Alternative prediction for the percentage change in 20 years*

Village Women	Village Men	Town Men	Town Women
10%	20%	90%	100%

The Village dialect would be mainly tonal and the Town dialect mainly a VOT contrast. In reality the situation is unlikely to be this clear cut, because the Kera travel between town and village and are in contact with people speaking all grammars. It would be interesting to rerecord the Kera in 20 years and observe which prediction, if either, is accurate.

Labov (2001) suggests that men base their grammar mainly on their mother's grammar and then make small differences based on the mean of the male speakers who are just a bit older than them. But women, while still starting with their mother's grammar, take notice of the outliers who have position in society. For the village, this would be the elders,

[13] Among the Kera there is often an age difference between husband and wife of about 20 years, so this makes the concept of 'a generation' hard to quantify, but I am assuming that the significant figure is the age gap between mother and child.

and they would pick the most conservative as a model. In town, the outliers would be those most influenced by French as this is considered prestigious. They pay less attention to the mean of all speakers. This is why the change in women is much quicker than among men.

It is interesting that the Town Women still use F0 more than the Town Men in perception. Presumably if they hear a tone difference, they make use of it. This implies that they are aware of the grammar of village speakers even if their grammar has changed.[14]

More detailed sociolinguistic discussion is outside the scope of this thesis. However, the gender and location issues raised here provide an interesting line of research for the future. It would be profitable to record more women especially if they are out of their normal context. It would also be helpful to find Village Men who are relatively isolated and unaffected by French. Finally, I would want to test the predictions of changes in Kera in 20 years time. A longitudinal study of this type could provide valuable material for the sociolinguistic debate on gender differences in language change.

5.7.3 Is there a critical age?

One more issue that is raised by these production results is that adults appear to be changing their grammar. This is particularly evident when Village/Town Men are compared with Village Men and Town Men. The three grammars are different, yet all that separates these men from the other two groups is that they started in one location and then arrived in the other location after the age of 16. If they could not change their grammar after 16, then they should still have the Village grammar. If however they somehow got sufficient contact with French as children to be counted as Town Men, then we would expect their grammar to be the same as that of Town Men. This raises questions for linguists who claim that adults cannot change grammars (Lightfoot 1998, Carlos Gusenhoven p.c.). This claim could still be true, as they may be changing their phonetics but not their grammar after 16.

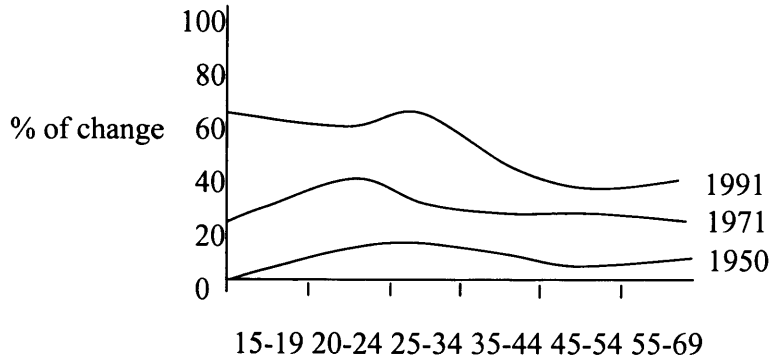
The Critical Period Hypothesis states that the ability to learn a first language is limited to the years before puberty (Penfield and Roberts 1959, Lenneberg 1967, Moskovsky 2001). Probably everyone would agree on this, but there is still a debate about how far this can be taken; for example, can a person learn a second language after this time,

[14] It might be hard to explain how the women have so much awareness of the village dialect if they stay in town, but there are always village men visiting town, and also a number of the town women still have family back in a village location. They may not visit often, but because of the distance, when they do visit, they generally stay for quite a while. So given the claims of some sociolinguists that women are more aware of other dialects than men, it is not inconceivable that they could recognise a village dialect even if not speaking it themselves. It could also be that some have developed two dialects, one for village and one for town. If so, it is likely that the dialect they would want recorded by me in town would be the prestigious town dialect. This is speculation, but it would be an interesting area for more recordings and research.

or a change in dialect or a minor change in grammar? There is also a debate about the boundaries of the critical age (if it does exist), and the cause. One theory concerning the cause is that access to universal language is no longer available after puberty. If this is true, then it would seem to be the case that if a person has learnt one language, he could still change his grammar based on what he has already learnt. It seems that the Kera can adapt their dialect as adults, but the extent to which they can do so is limited.

Chambers (2003) notes that there are very few examples of prosodic change in sociolinguistic literature. One language that has been described with prosodic change is Japanese. In the city of Tsuruoka in northern Japan, there has been a rapid change from a fairly isolated city in 1950 to a thriving industrialised city just a few years later. Yoneda (1993) has conducted three surveys in 1950, 1971, and 1991 into the phonetic and phonological changes that have taken place there. Segmental changes include an increase in labialization, palatalization, voicing, nasalization, and vowel shifts, but the change which is of most interest to us is the change in pitch accent. He claims that this is a change on lexical items rather than a change of grammar. The changes are of the form: LH > HL and LHL > HLL. The relevance of this to this thesis is that Yoneda has plotted the effect of age on the amount they have changed. Because he has taken three surveys twenty years apart, we can see how speakers of aged 20 in 1950 spoke twenty years later. As we have seen in Kera, it seems that some change is possible even in adults.

(69) *Amount of change in Japanese pitch accent according to age and year (Based on Yoneda 1993)*



Consider a 20 year old in 1950. At that point the amount of change is approximately 15%. By 1971 when our speaker is 41, the change is around 30%. Evidently the speaker can undergo some change as an adult, and it continues because in 1991 when he is aged 61, he has undergone 40% of change.

Similar curves occur for the segmental changes except that the segmental changes occurred before the prosodic changes, and by 1991, the change was almost complete.

Chambers (2003) comments that segmental phonology generally changes first with prosody lagging behind. He accounts for this by saying that prosody is learnt very early so it is the hardest to dislodge. The Kera situation involves both segmental and prosodic change, so it suggests that changes can occur simultaneously in both.

It would seem from the Japanese example that when the phonological patterns of a whole community are changing, adults do have some ability to change too even if this is not such a dramatic or swift change as for younger members of the community. This supports the results of the Kera Village/Town Men. They have not completely adopted the town grammar, but their grammar seems to have changed from the village grammar that they presumably had as children. This means some change has taken place in them since they became adults.

Evans and Iverson (2006) have tested university students from the north of England who have moved to London. Their results show that subjects in early adulthood can change their spoken accent while attending university to bring it more into line with Standard Southern British English which is the prestige accent of English and the accent of education. The evidence for change in perception was less clear although there was some link between production and perception. It would seem that like the young adults in this test, the Kera Village/Town Men can also change their production and perception to some extent.

If adults can change their grammar, does this mean that the age of the speaker is not as important as some would suggest? Chambers (2003) suggests that there are several stages in acquisition. From before birth up to age 5, the parents have the main influence. Then from 5 to 13, the peers have the greatest influence (in most cultures 5 is the age of going to school). As teenagers they will probably use slang to distance themselves from their elders. Then as adults, they will adopt professional vocabulary, or vocabulary that associates the speaker with particular social groups. People who move between the ages of 7 and 13 vary in their ability to completely adapt to the new dialect. After 13, he claims that if a speaker moves to a new speech community they will not achieve a completely native dialect, but they can still change. Chambers says that language is used for the purpose of social solidarity. People will adopt the dialect of the people with whom they wish to identify. But their ability to do this slows down after the age of 13 at least in the area of phonology (New vocabulary is common in teenage groups and in the workplace). Other support for a critical age of around 13 comes from Chambers (1992), Trudgill (1986), and Payne (1980). Labov (2001) on the other hand chooses to use the age of 17 in at least one of his experiments.

To defend the claim that 13 is the cut off point for completely adopting a new dialect, Chambers sites a study of 6 Canadian children who moved to England at different

ages. In Canada, the vowels in words like bobble and bauble, Don and Dawn would all be the same, but in London they are not. Each of those tested had been in London for about two years. He found that the amount they acquired the new pattern was as follows:

(70) *Results of study on vowels of 6 Canadian children in England, Chambers (2003)*

Age	% new pattern acquired
9	90
13	80
13	9
14	3
15	8
17	2

Obviously one test with six children proves nothing, but Chambers has found this to be a common pattern. Note that the two 13 year olds gave very different results. Chambers claims that this supports the critical age being about 13. To study the possibility of a critical age in our Kera study, we would need more speakers and more data than we have. But it does seem that there is a point beyond which the changes are less strong and the speaker may never fully adopt the new grammar, but this doesn't mean they stop changing altogether. The Kera results suggest that they can still make phonetic changes and possibly changes in grammar as adults, but that the changes are less categorical and complete.

The Kera situation implies that both L1 and L2 can change in adults. Sankoff (2002) notes that in postcolonial situations, there is often a slow change from one language to the other and this results in changes occurring in the phonology of the colonial language as spoken by the people who are moving towards adopting it. Changes in the first language are usually limited to borrowings. The claim is that most language contact situations are unidirectional without change in both languages. However, in Kera, it is clear that change is occurring in the relationship of VOT and F0 in both languages as we saw when comparing (50) with (51). This should be of interest to sociolinguists as it appears to be rare. There is a case recorded of pitch, vowel harmony and stress being affected in the second and third languages of trilinguals who speak Kalenjin and who are moving towards speaking more Kiswahili and English (Muthwii 1994). But there is no mention of any phonological changes in Kalenjin except possibly in borrowings.

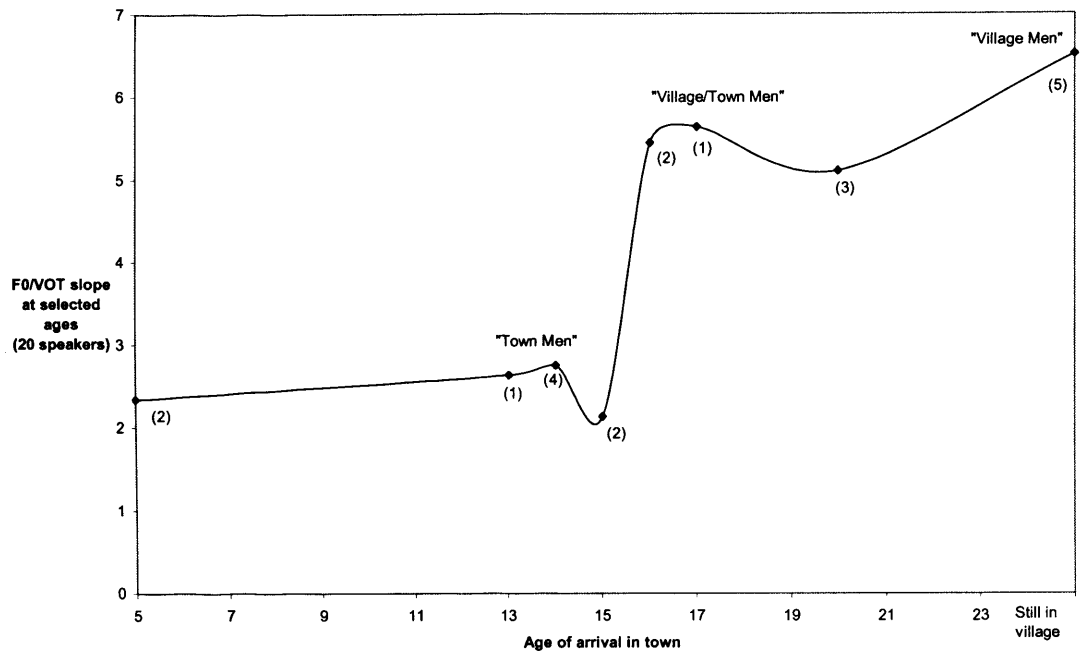
Rather than a critical age, Best (1995) and Flege (1999) suggest that the ability to perceive new categories may be lost if not used for a while. This would mean that a person who continues to learn new languages through childhood would presumably not have a critical period, while someone who only learnt their own tongue in childhood may have

more trouble in learning new languages in adulthood. The majority of Kera speak several languages[15] at least to the level of using them in the market, so this theory would imply that they should have an older 'critical age' than others. It could explain the fact that the division between Town and Village/Town speakers seems to come at the age of around 16 rather than 13. It could also explain why the Village/Town Men seem to change their pronunciation with relative ease as far as changing phonetic details is concerned, but that they tend not to arrive at the Town grammar because this would require too much of a categorical difference from their original grammar. The Kera data fit well with the concept that the critical age moves depending on whether the speaker has continued to exercise their language learning skills. But as the theory does not yet have much experimentation to back it up, our conclusions must stay tentative at this point.

As just mentioned, in the division of Kera speakers into Village/Town and Town Men, the cut off age that I have used is 16. This was chosen as it appeared to be a natural point for dividing the data and because it made the two groups roughly the same size. But there is some further justification for using this age. The graph below plots the ages of men when they came to town against their use of F0 in voicing perception. The use of F0 is calculated according to the slope of the graph of F0 at different values of VOT for each subject. A slope of 6 or 7 indicates a very significant use of F0 whereas a slope of 2 suggests that the F0 use is relatively minor. Where more than one person came to town at the same age, the slopes have been averaged. The graph is based on 20 subjects for whom the biographical facts were known or could be estimated. The number of subjects at each point is indicated in brackets. The graph includes Village Men who have never lived in town for comparison.

[15] As well as French, many male speakers can also speak Tupuri (which is spoken in the nearest town), a little Arabic and one or two neighbouring Chadic languages such as Musey.

(71) *F0 use in perception plotted against age of arrival in town*



The difference between age 15 and 16 appears dramatic and this gives support to the use of 16 as the age for dividing between the two groups. It should be said that this graph relies on a small number of subjects and the ages are approximate, so the author is aware that in reality, the results may not be so dramatic. This graph is not reliable enough to use as proof of a 'critical age' because of low numbers of subjects. But it does give some support to the theory while noting that the late arrivals to town do still adapt their grammar to some extent.

A complete scientific study for the purposes of investigating the critical age concept is beyond the scope of this thesis, as it would require many more subjects and would need an investigation into the effects on VOT as well as F0, with more of a focus on the production data. I would also need to investigate the age of the subject when recorded as well as the age of coming to town, and any other influences they might have from contact with French or other languages. I would need to question whether the age of 16 is significant for lifestyle reasons, as it could be that all who move to town before 16 go to school in town whereas all those who move later simply join the Kera community with less opportunity to hear French. For these reasons, we need to remain tentative in our use of the above graph, but we can at least say that it is compatible with Labov's age of 17 or 18 for a 'critical age' and with the claims of Chambers (2003) that 13 year olds differ in their amount of adaptation, but that after this age, much less adaptation is possible.

This thesis does not claim that no adaptation is possible after the age of 16. The difference between Village/Town and Village Men shows this. Other studies have shown

that adult adaptation is possible, recall the Evans and Iverson (2006) study on students. Another interesting study of adult adaptation is that of Harrington et al (2000) who studied the changes in the vowel formants of Queen Elizabeth II as she gave her Christmas broadcasts over a stretch of 40 years. Although already an adult in the 1950s for the first of the recordings which were analysed, her dialect is shown to change in later recordings, particularly around the late 1960s in the same direction as changes that were taking place in the Standard Southern British dialect at the time. They rule out the possibility that the changes occur from hyper-articulation, aging or any geographical changes, and conclude that the Queen was able to change her dialect as a result of changes in the speech of the community.

I conclude then that, for Kera at least, the amount of change in dialect appears to decrease around the age of 14-17, but we need to remain open minded as to whether this decrease is the result of a critical age of around 16 or a more gradual decrease that happens to be noticeable at this age. It is clear that adaptation is still possible after this age, although it is likely that the original dialect will remain detectable to other Kera speakers.

We have been noting the influences on Kera speakers when exposed to a town dialect, but we shouldn't underestimate the effect that French might have in causing these speakers to abandon Kera altogether. At the moment, they are trying to keep their Kera, and as they tend to live in Kera communities, that may remain possible. But Preston (1989) has observed that when one language has more prestige in a bilingual situation, there is often a sharp attrition of the second language typically within two or three generations. It is to be hoped that this will not happen for the Kera speakers in town, but it may also mean that we have a unique opportunity now to see the phonological changes in operation.

5.8 Conclusion

This chapter has several implications for the interaction between phonological and phonetic structures in tonogenesis and subsequent changes in contrast. It has also highlighted the importance of acoustic measurements as a basis for any analysis. Kera provides a rare example of a language undergoing tonal changes which can be observed and measured.

We have found that the Kera use both F0 and VOT cues to mark the 3-way tonal contrast. As the F0 value increases, so does the VOT value. F0 is the major cue and VOT enhances the tonal contrast. But the VOT use varies depending on the contact with French and probably also the amount of exposure to the French orthography as a child. Village children also learn French at school, but the teachers in primary school can be Kera, and they therefore speak French with a Kera accent. The effect of French is greater in town where the teachers are probably not Kera, and quite possibly don't speak a tone language with consonant/tone interaction.

In excited speech, VOT is used less but the F0 value has a greater range. There is still a relationship between VOT and F0, but a new trend line is used when the speech is higher or faster. This implies that the overall relationship is between VOT and tone rather than between VOT and the phonetic F0 value.

Even though Town Women appear to be moving towards a grammar with no tonal contrast, it is unlikely that a positive VOT could sustain a 3-way contrast. Such a contrast is unattested. But they may be moving towards a 2-way contrast where one of the contrasts is lost. If contrasts were lost in general, it may be that the tonal contrast would be retained for minimal pairs.

This chapter has presented a volume of new data in terms of production and perception results, but we have not looked at other cues that might be playing a part such as voice offset time and spectral tilt. These do not appear to play a major role, but they could still be enhancing the tonal contrast in some way. This is an area where further research is needed.

Although unreliable without the F0 cue, VOT does add to the clarity of the communication and for the majority of Kera speakers, it has some role to play in enhancing the tonal contrasts. The enhancement may vary according to the speaker, but this is also giving the listener extra sociolinguistic information about where the speaker comes from. This means that the VOT cue still has an important role in Kera even though for some speakers it is not contrastive.

At the end of this chapter, we saw that the difference in perception between the genders was possibly caused by greater awareness of the language of prestige among women. We also discussed how the ability to change dialects decreases somewhat with age, but that adults still retain some ability to change. The predictions of sociolinguistic models of language change can be applied to the Kera situation, and it will be interesting to see if the change occurs as predicted in the coming years.

The main focus of this chapter has been that contact with French is having a major effect on the relationship between VOT and F0, and this is affecting the grammar of town speakers. Kera has moved through the following changes:

(72) *Changes in diachronic and synchronic Kera*

a. 2-way voicing contrast, no tonal contrast (Proto-Chadic)

b. 3-way tonal contrast, voicing lost (Village Women, through tonogenesis)

c. 3-way tonal contrast, VOT enhancing L tone (Village/Town Men)

d. 2-way tonal contrast, 2-way VOT contrast (Town Men in contact with French)

e. Move towards 2-way VOT contrast, no tonal contrast (Town Women)

The author is not aware of any claims about other Chadic languages where these sorts of changes are occurring, but in the light of these results there seems to be justification for reassessing the other Chadic languages which claim to have depressor consonants, and to take acoustic measurements to investigate the F0 and VOT relationship further.

In the next chapter, we return to phonological concerns by considering the issues that are raised by these results such as whether Kera has tone or voice spreading and the best analysis and features for describing the grammars at each stage.

Chapter 6

Tone and voicing interaction: Theoretical issues

6.1 Introduction

We have already established that Kera has three tones: H, M and L and that in the Village Women variety of Kera, there is no voicing contrast. However, in early papers on Kera (Ebert 1976, 1979; Pearce 1999) and in the orthography, Kera is usually shown as having a voicing contrast in the obstruents. This has led some linguists to use Kera as key evidence of the existence of non-adjacent consonant to consonant voicing spread (Odden 1994, Rose and Walker 2004, Uffmann 2003, p.c.). In this chapter, we will consider the evidence for voice spreading in Kera, noting that only a few languages show possible long-distance consonant-to-consonant spreading and that the claim is controversial. Gafos (1998) questions whether long distance spreading of this type takes place in any language. I will give evidence that when spreading takes place in Kera, it is not the voicing that spreads, but rather the tone. As Kera is key to the argument for voice spreading, if it is eliminated from the languages showing this phenomena, we are led to ask whether long-distance consonant-to-consonant effects exist in any language.

Once we have decided that the spreading feature in Kera is not voicing, we are left with the task of deciding exactly what phonological features are being used in the contrast. One obvious choice would be to say that this is a pure tone contrast, involving purely tonal features. If I use tone, I can describe the village situation adequately; but to cover the changes in grammar between village and town as described in the last chapter, I need a more holistic approach to the features. Much work has been done recently on the laryngeal gestures that combine to produce tone, VOT and other phonation types. I need features that can cover both tone and VOT changes. The first model to attempt to do this was Halle and Stevens' laryngeal model (1971). In this chapter, we will look at this model and more recent laryngeal models to consider which works best for Kera. We will conclude that a slightly revised version of the Halle and Stevens model captures the changes in dialect well and provides a simple and convincing account of the changes taking place between grammars. This is not to reject more recent models which certainly have plenty to offer in our understanding of laryngeal features and their use in the world's languages, but for Kera, a simpler model in terms of the univalent features [Slack] and [Stiff] will be seen to be sufficient. With this model, we will move on to investigate the feature bearing unit. In chapter 4, we saw that the TBU was best described as the foot. We will now extend this to the features [Slack] and [Stiff] and establish that the feature bearing unit (FBU) for these

two features is also best described as the foot, with the feature aligning to one or both edges of the foot.

The structure of this chapter is as follows: We will look first at the voice spreading issue, and in this section we will consider how tone spreads onto affixes and also loanword data. Evidence for tone spreading will be presented including a statistical comparison of nouns marked for voicing from a Kera lexicon with a list of nouns which have been classified for tone. We will see that the tone spreading theory accounts for the data better than the voice spreading theory. The second half of the chapter will focus on the question of which laryngeal features model to use and the application of the Halle and Stevens (1971) model in establishing the feature bearing unit as the foot. We will see how this model gives us an analysis for all of the tone facts that concern nouns and verbs. Finally, we will discuss the comparative merits of two descriptions of the tonal facts, the first in terms of spreading of features over segments and the second in terms of alignment to the edges of the foot. The first is more conventional and covers all the facts, but we will conclude that the second has the advantage of capturing the importance of the foot for Kera tonal spreading.

6.2 Claims of voice spreading in Kera

Rose and Walker (2004), Uffmann (2003) and Odden (1994) have all claimed that Kera demonstrates long-distance voicing spread based on the lexicon and grammar of Ebert (1976, 1979). Until recently, Kera has been described as having a voicing contrast in obstruents and apparent alternations in the voicing in affixes. Ebert's description of Kera is closest to the Village/Town dialect, so for the remainder of this section, I will use this same dialect to refute the arguments for voicing-spread. The task of linguists looking at Kera data has not been aided by the fact that words have not necessarily been marked with tone. So examples such as (1a) have been seen as a demonstration of the feature [voice] spreading left onto the prefix, whose underlying voicelessness surfaces in (1b).

(1)	a.	/k- bɨ̀rwá-ŋ/	gɨ̀bɨ̀rwáŋ	'white (pl.)'
	b.	/k- mārwā-ŋ/	kə̄mārwāŋ	'new (pl)'

In contrast to these linguists, Gafos (1998) claims that no long-distance consonant-to-consonant effects exist.[1] He claims that apparent examples of long-distance effects are all cases where a secondary place of articulation can spread through adjacent sounds without affecting the primary articulation. So for example if the tongue body is used for the sound,

[1] Gafos does allow the OT notion of correspondence as do Rose and Walker, but he uses it in a more restricted way than they do. His approach has similarities to reduplication in OT.

the tip of the tongue can still spread some other feature at the same time, and this may appear to be long distance spreading, while it is in fact local spreading. But this explanation does not extend to the putative long-distance voicing spread examples because with all vowels being phonetically voiced, a local spreading of [+voice] (contrasting with [-voice]) through the vowel would not be possible. So another argument is needed to eliminate those. Rose and Walker (2004) give examples of supposed long-distance voicing spread from Chaha, Ngizim, Ngbaka and Proto-Indo-European where only agreement within the root is involved. I could argue that these are simply historical and non-productive. Kera is the only language among their examples which has apparent allophonic effects. It therefore provides their strongest evidence and is a key example in their argument. But the Kera case is not as clear cut as they assume. Hansson (2004a,b) has also entered the discussion on long distance voicing spread. He suggests in passing that Kera tones might be influencing voicing and that this may account for the spreading effects, but he does not elaborate on the subject further. In this thesis, I show that most dialects of Kera have no voicing contrast. My claim is that all of the apparent voicing spread in Kera can be accounted for by tone spreading, with resultant changes in VOT. Kera does not have a distinctive feature [voice], so it cannot have long-distance voicing spread. In fact, phonetic studies in Pearce (2005b) and in chapter 5 in this thesis have demonstrated extensively that VOT co-varies with F0 and that tones are contrastive while the VOT is not. In this section, I now give key arguments from cases where tonal spread can explain the apparent voice changes. I claim that the effect of voicing spread comes from L tone spreading. When this happens, obstruents get a shorter VOT due to the relationship between F0 and VOT, and this is perceived as voicing.

To argue against a voicing spread analysis, we will look at the counter-evidence from the affixes: K-, -Ki/Ka and –T, the counter-evidence from loans and finally the counter-evidence from a statistical analysis of the lexicon, but firstly we will consider what claims have been made.

The voice-spreading claims of Rose and Walker (2004), Uffmann (2003) and Odden (1994) are based on two observations:

(i) The K- prefix 'plural' apparently has two alternants: [k] and [g]. It is claimed that the voicing spreads left onto the prefix. For the following examples, a voiceless grapheme is used for a short VOT. This is the symbol that is used in the orthography and the data which Rose et al have used. In (2a), the plural prefix is voiceless, matching the other obstruents in the word. In (2b), the prefix is voiced, again matching the voicing of other obstruents in the word.

(2)	sg.	pl.	
a.	kúmná	kɨ̄kámnɨ̂	'chief'
	tāatá	kɨ̄tāatáw	'big pot'
	táasā	kə̄táasāw	'cup'
b.	bɨ̀rwá	gɨ̀bɨ̀rwáŋ	'white'
	dàarà	gə̀dàarà	'friend'
	àzrá	gàzráw[2]	'gazelle'

(ii) Within a word, the obstruents usually agree in voicing. In (3a) all obstruents are 'voiceless', in (3b), they are all 'voiced'.

(3) a.	tɨ̄rɨ̄ŋká	'old (f)'
	kūpūrkí	'billy goat'
	tép□	'to gather'
b.	agònɔ̀gì	'grudge'
	gùjùglùgì	'granary cover'
	bèzɛ̀rnɛ̀gì	'fox'
	ɗɨ̀bɨ̀rgɨ̀	'chicken'

The above examples are compatible with a voicing spread account of Kera. We now examine some counter-examples.

6.3. Counter-evidence for voice spreading claim

6.3.1 Counter-evidence from affixes

The words in (4) contain voiced obstruents, so a consonant-to-consonant voice spreading account predicts voiced prefixes. In contrast, a tone account predicts that if the first syllable has high tone, the prefix will have a long VOT and will therefore be perceived as voiceless. This is exactly what we find. So (4) supports the tone account.

[2] Rose and Walker (2004) excluded Kera fricatives from the argument. But they behave in the same way as stops. So called voiced and voiceless fricatives differ in duration. Short fricatives generally behave like stops with short VOTs. It seems likely that fricatives were at one time contrastive for voice and that when voicing was lost on stops, it was equally lost on fricatives, but that they retained some durational differences.

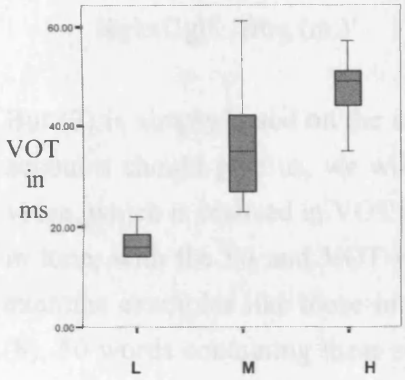
(i) K- prefix

(4)

sg	pl		
ágày	k-ágày	'hoe'	(pronounced [kə́gày])
ágàmlà	k-ágàmlà	'bull'	(pronounced [kə́gàmlà])[3]

A careful study of the K- prefix in the Village/Town dialect shows that there is no binary split between so called voiced and voiceless as the following graph shows.

(5) *VOT measurements for 33 K-prefixes separated according to tone (Village/Town dialect)*



No voice spreading account can deal with this. The three tonal groups give significantly different results and they do not easily group into a binary division of voiced and voiceless.

Further examples to support the tone account come from Proto-Chadic (Jungraithmayr and Shimizu 1981, Stolbova 1996, 2005). It would seem that the voiceless prefix has changed voicing because of the L tone in the first syllable. It cannot be because of a voiced obstruent because there are no other obstruents in the examples given.

[3] Observant readers might notice that this word breaks the tonal patterns for feet described elsewhere in this thesis. I presume this has come about because the initial [a] was originally a toneless prefix but has now become part of the noun in a frozen form which preserves the non-low nature of the tone. There is some variation in how the plural form is pronounced, but when pronounced with a L tone throughout the word, it also has the short VOT onset [g].

(6) *Evidence from Proto-Chadic that prefix matches tone not voicing*

	Proto-Chadic[4]		
With f. prefix:	*t-làarɨ	[(dàa)(ɨ̀:)]	'friend'
With pl. prefix:	*k-làarɨ	[(gə̀làa)(ɨ̀:)]	'children'

(ii) -Ki/Ka suffix

Rose and Walker also claim voicing spread in the –ki/ka (m./f.) suffix. For this suffix, masculine words have the –ki/gi ending, while feminine words have the –ka/ga ending. In (7), both the voicing account and the tone account can adequately cover the facts.

(7) /kísírkí/ 'black (m.)' /sárká/ 'black (f.)'
/ãgèz□gǐ/ 'frog (m.)' /dàygà/ 'jug (f.)'

But (7) is simply based on the orthography. If we consider more carefully what these two accounts should give us, we will note that a voicing account predicts a 2-way contrast in voice, which is realised in VOT alternations, while a tone account predicts a 3-way contrast in tone, with the F0 and VOT values co-varying in line with the tones. We can therefore examine examples like those in (7) more closely to see which set of predictions holds. In (8), 50 words containing these suffixes were measured for VOT. There appears to be a 3-way split.

(8) *Mean VOT of –K suffixes, tested on 50 words*

32 ms	Preceding H tone.
22 ms	Preceding M tone.
9 ms	Preceding L tone.

(All significantly different, $p < 0.01$.)

It would seem from this that the orthography symbol for <k> is misleading as it covers a range of VOTs with an approximate measurement of 22 ms preceding M tone (or H with undershoot) and an approximate measurement of 32 ms preceding H tone. The linguists

[4] Jungraithmayr et al do not mark tones on Proto-Chadic, but they give the present day forms of the word in a number of languages. In these examples, the languages closely related to Kera agree on the tone but not on the voicing, so this implies that at some point tone was introduced, and then at a later point, the voicing changed in Kera but not in all other languages. Proto-Chadic evidence on its own could not make a case because there are too many unknowns, but it does supply useful corroborating evidence.

who made the voice spreading claims did not have access to these measurements and therefore assumed that all <k> symbols in the orthography were indistinguishable from each other. In fact, we should be saying that the K- prefix and the –K suffix both have three alternants which differ in VOT. These three alternants are not phonologically contrastive, but they differ phonetically in VOT measurements which are different enough to be perceived.

There is a further alternating suffix which is not discussed by Rose et al. This is the –T verb suffix to mark habitual action.

(iii) –T habitual suffix

The –T suffix has two apparent alternants [t] and [d]. In (9), two verb paradigms are given. These verbs are tonal minimal pairs, but a closer inspection shows that the VOT of the –T suffix differs according to the tone of the suffix which follows it. The VOT values are given in parentheses. The box surrounds the L tone examples where the affix is perceived to be [d] and the VOT is low. As these two verbs are minimal pairs, the apparent change in voicing cannot be due to any voicing spread as all the consonants are the same in the two verbs, and they are classified as 'neutral' for tone. In Kera, implosives act like sonorants in being neutral for tone, so the tone does not originate with the consonants.

(9)	UR	lɔ́ɓɛ́ 'to convince'			lɔ̀ɓɛ́ 'to fatten'[5]		
1 sg	lɔɓ-T-n	lɔ̄ɓtɔ̄n	M	(23)	lɔ̀ɓdɔ̀n	L	(12)
2 sg m	lɔɓ-T-m	lɔ̄ɓtɔ̄m	M	(25)	lɔ̀ɓdɔ̀m	L	(16)
2 sg f	lɔɓ-T-i	lūɓti	M	(35)	lùɓdi	L	(15)
2 pl	lɔɓ-T-ŋ	lɔ̄ɓtɔ̄ŋ	M	(19)	lɔ̀ɓdɔ̀ŋ	L	(17)
3 sg m	lɔɓ-T-ú	lúɓtú	H	(32)	lùɓtú	H	(30)
3 sg f	lɔɓ-T-á	lɔ́ɓtá	H	(29)	lɔ̀ɓtá	H	(23)
3 pl	lɔɓ-T-ə́y	lúɓtə́y	H	(33)	lùɓtə́y	H	(38)

This is just one example, but in (10), the same measurements are repeated on 240 words with –T suffixes.

[5] Like other Chadic languages including Ngizim (Hansson 2004b), ɓ does not act as if it's voiced.

(10) *Mean VOT of –T suffixes, tested on 240 words (3 speakers)*

20 ms	Preceding H tone.
16 ms	Preceding M tone.
11 ms	Preceding L tone.

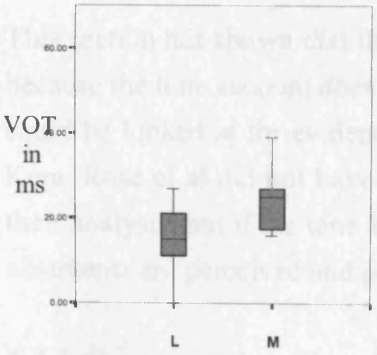
(All significantly different, $p < 0.01$.)

These examples suggest that the tone account fits the facts best. We have seen that the change in –T cannot be voice spreading. The minimal pairs example in (9) will not allow such an account. Clearly in all of these examples VOT is co-varying with tone. These affixes alternate in voicing as the tone changes and the alternation is not caused by the voicing of any obstruents in the root.

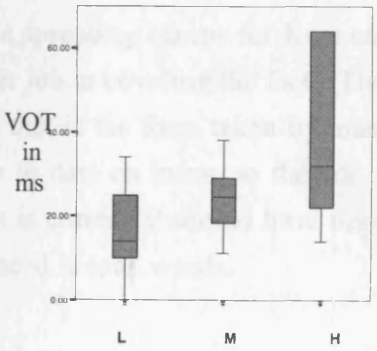
As with the prefixes discussed above, the –T suffix does not have a binary split between voiced and voiceless. The VOT value is affected by the tone and also by contiguous consonants as the next few graphs show. In each case, the tonal effects can be seen in addition to the phonotactic effects. The speaker has the Village/Town Men dialect.

(11) *VOT Measurements of T in CVC-T-V*
(Speaker A, approximately 30 words for each graph from natural speech)

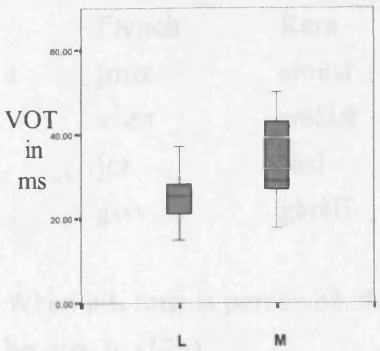
1. CVNTV (N, nasal)



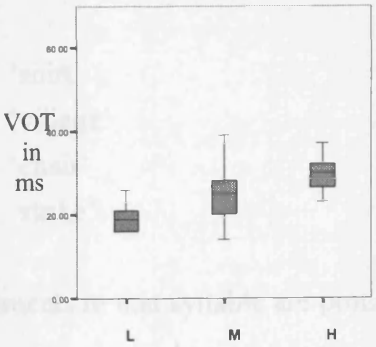
2. CVRTV (R, liquid)



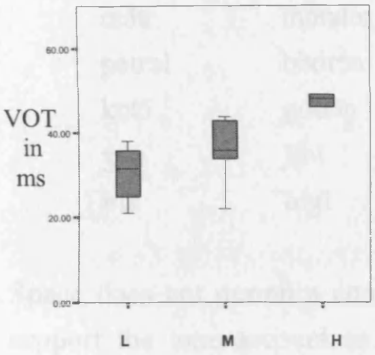
3. CVKTV (K, obstruent)



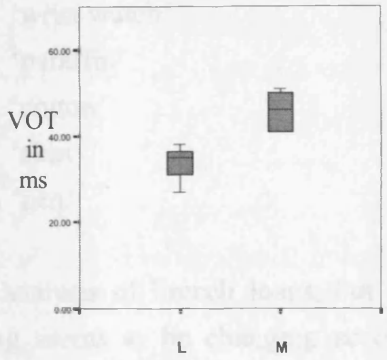
4. CVBTV (B, implosive)



5. CVYTV (Y, glide)



6. CVSTV (S, fricative)



All results are significant with $p<0.05$ except Y: L, M and B: M, H

This section has shown that the voice spreading claims for Kera cannot be based on affixes because the tone account does a better job in covering the facts. There is another area which could be looked at for evidence and that is the form taken by loan words which enter into Kera. Rose et al did not have access to data on loans, so they do not use any examples in their analysis, but if the tone account is correct, it should have implications for how voiced obstruents are perceived and pronounced in loan words.

6.3.2. Counter-evidence from French loans

Loans in Kera can come from several languages, but the main source is French. French is not a tone language, but when the Kera perceive a final accent in French, this is often realized as a H tone in the Kera word. This H tone may spread onto the final epenthetic vowel. In this case, the preceding obstruent becomes voiceless as seen in (12a.).

(12) *French loans into Kera*

	French	Kera	
a.	ʃmiz	sīmísí	'shirt'
	vilaʒ	wɔ́lásí	'village'
	ʃɛz	sɛ́sí	'chair'
	grɛv	gərèfí	'strike'

When a L tone is perceived, the obstruents in that syllable are pronounced as voiced, as can be seen in (12b).

b.	kɔʃɔ̃	gòzɔ̀ŋ	'pig'
	mɔ̃tr	mɔ́ndɔ̀r	'wrist watch'
	petrɔl	bɔ̀drɔ́n	'paraffin'
	kɔtɔ̃	gòdɔ̀ŋ	'cotton'
	ʒyp	jìbì	'skirt'
	bik	bìgì	'pen'

Space does not permit a complete analysis of French loans, but the examples above do support the tone account as voicing seems to be changing according to the tone. The voicing account, on the other hand, cannot explain all of the changes in voicing that occur, especially when the result has a mismatch of voicing throughout the word, such as in *gərèfí* (French: *grɛv* 'strike'). The voicing account claims that Kera prefers voicing to agree throughout the word, so changes which cause less agreement than in the original language cannot be accounted for.

We have already seen that the voicing agreement claims are based both on affixes and on agreement in monomorphemic words. In the next section, we will look at a small but significant group of words which do not agree in voicing, the voicing account again has problems in explaining the Kera data. In contrast, the tone account can explain these exceptions.

6.3.3 Counter-evidence from statistical analysis of lexicon

Uffmann (2003) cites several Kera words which agree in voicing, a few of which were given in (3). He acknowledges that there are exceptions, but he still claims that this shows voicing spread. Uffmann is not in a position to know how many exceptions there are, but a quick count based on the orthography in the present lexicon gives the following results:

(13) *Agreement in voicing in the Kera lexicon*

Matching or irrelevant	53 % of words have less than two obstruents.	
	20 % of words have just voiced obstruents	
	18 % of words have just voiceless obstruents	
Mismatching	9 % of words have a voicing mismatch	8 % have voiced obstruent + voiceless obstruent[6]
		1 % have the opposite mismatch.

From these results, we can say that Kera appears to have a bias towards voicing agreement. But my argument is that this effect is produced because VOT co-varies with tone. The tone patterns can account for the apparent agreement in voicing. Unlike the voice-spreading argument, tone patterns can also explain why the agreement is not 100 %.

For L tone syllables, I claim that the onset obstruent will have a VOT of 0-20 ms which may be perceived as 'voiced', certainly by linguists who speak languages such as English where 20 ms is roughly the cut off point between two phonemic categories. This means that in the lexicon, these obstruents have probably been recorded as voiced.[7] For M and H tone syllables, the VOT is longer, and these are generally perceived as voiceless.

The goal of this investigation is to find the percentage of words which contain at least two obstruents and a tone pattern involving both L and H. According to my claims, these words should be perceived as having a change in voicing as well as tone. If the percentage of these words (with a tonal mismatch) is close to the 9% of words which have a voicing mismatch in the lexicon, then we can conclude that the tone is affecting the apparent voicing changes.

For this investigation, I examined 1132 nouns already classified for tone. I divided the 1132 nouns according to their tone patterns, the number of syllables and the foot structure[8]. I noted the onset of each syllable as an obstruent (O) or a non-obstruent (N). Only obstruents show changes in VOT which are interpreted as voicing. In words with

[6] Given the unevenness of 8% versus 1% in this cell and the one below, it could be suggested that maybe voice spreading does occur, but only to the left. In answer to this, I would refer to section 6.3.1 where I discuss the –T suffix. Directional voice spreading could not account for these cases.

[7] Early decisions about voicing in the orthography were made by expatriot linguists who spoke German, English and bi-lingual English and French. When Kera people were asked for voicing judgements for ambiguous words there was generally a lot of disagreement. This is probably because the words in question had a VOT of around 20-30 ms.

[8] The foot structure is relevant because the tone bearing unit is the foot, not the syllable.

more than two syllables, I considered the onset of the first syllable in each foot based on the fact that the TBU is the foot (see chapter 4 and Pearce (2006a)).[9]

The full results are given in appendix 3, but a simplified table is produced below. In this table, rounded percentages replace the actual figures. The shaded cells indicate the categories where two obstruents occur with a change between H and L tone. These are the words where I would expect to see a voicing mismatch.

(14) *Tone patterns in 1132 Kera nouns, shown as percentages*

				Expected apparent voicing change	
		H, M, or L	MH or HM	LH	HL
1 syll		11			
2 syll	2 obst	15	5	4	2
	other	23	8	6	2
>2 syll	2 obst	4	4	2	1
	other	6	4	2	1

The sum of the shaded cells total 9 %. So 9 % of all words would be expected to have a voicing mismatch because of the combination of H and L. This fits in well with the results I have already obtained from the lexicon. We found in (13) that the voicing mismatch in the lexicon was also 9 %. The other figures in (15) do not match exactly (the 1132 tone classified nouns were not necessarily the same nouns as those that were used from the lexicon), but the results are close enough to suggest that we are comparing like with like and that the voicing mismatch is caused by a tone mismatch.

[9] When this test was run, it was not clear that there was any difference between considering the first or the second consonant in the foot, so the first consonant was chosen as there are more obstruents in this position. In subsequent work which is recorded later in this chapter, it has become clear that the first consonant is the most reliable choice for this task.

(15) *Comparison of lexicon voicing with prediction from tones*

	<2 obstruents	**voice agreement**[10]	**voiceless agreement**	**voiced/ voiceless**	**voiceless/ voiced**
voicing in lexicon (Kera orthog.)	53 %	20 %	18 %	8 %	1 %
prediction from tones	63 %	8 %	20 %	6 %	3 %

From this we can see that both the lexicon and the prediction from tones gives a 9% mismatch in voicing. We have already said that the voicing spread claim has no account for the existence of the 9% of words where voicing does not agree, but the tone account can adequately explain the 9%. The voice spreading claim has difficulty explaining the affix alternates and it cannot explain the forms of French loans. Added to this, the voicing claim is controversial because it involves non-local spreading.

In contrast to this, the VOT/tone claim does cope with the Kera voicing facts. This view says that as [voice] is not a feature in Kera, it cannot spread. When spreading takes place, it is the tone that spreads. This theory accounts for the VOT values in the K- prefix and the –T suffix. It explains why the Kera have trouble deciding where an obstruent is voiced in ambiguous cases. It gives a plausible explanation for the changes in French loans, and it also explains why 9% of words have a voicing mismatch. In addition, tone spreading is common in many languages and is not controversial.

Therefore Kera cannot be used as key evidence in favour of long-distance consonant-to-consonant voicing spread and this thesis raises serious questions about whether long-distance effects do exist. We cannot conclude on the basis of one language that long-distance consonant-to-consonant effects definitely do not exist, but the onus is on the linguists who claim these effects to find another language that demonstrates voicing alternations as a result of voicing spread[11]. We have seen that Kera cannot be used as evidence of this.

[10] There is a surprising discrepancy between the two numbers in this column. There is no obvious explanation for this except to say that the two lists of nouns differed in content. The lexicon list is probably representative of Kera as a whole, but in the list of nouns marked for tone, it may be that words with L tone and two obstruents were slightly under represented. It is unlikely that this would significantly change the main result of the comparison between the shaded cells.

[11] Rose and Walker (p.c.) have found another language which they think replaces Kera in this argument, but I do not have details.

So we have established that in Kera, there is no long distance voicing spread. In some dialects, the obstruent VOT is dependent on the tone of the syllable. Tone does spread in certain cases, but it does not skip syllables. For most Kera dialects, tone is phonemic and VOT enhances the tone. In the light of these conclusions, there is a need to reconsider the claim of long distance voicing spread in the other languages which have been claimed to have voicing spread, such as Chaha, Amharic, Ngizim, Hausa, Ijo, Aymara, Yabem and Zulu. Hansson (2004a,b) has begun to do this.

It should be noted that although our discussion raises the question as to whether long-distant voicing spread exists, it does not prove that there is no long-distance consonant assimilation in general. McCarthy (2006), Hansson (2001), Rose and Walker (2004) and Walker (2000a,b) all claim that this assimilation is accomplished by segmental correspondence rather than autosegmental linking. This means that assimilation is more likely to occur with segments that have similar features. McCarthy gives the example of Chumash which apparently has a consonant harmony process where sibilant consonants agree in [anterior] with the rightmost sibilant in the word. The work on correspondence theory (McCarthy and Prince 1995a, 1999b) is interesting and may well be the way forward for understanding these difficult cases, but unfortunately, Kera voicing cannot be used as an example to support this theory.

We have now considered the Kera tonal system in detail and acknowledged the link to voicing and VOT, while establishing that Kera does not have a [voice] feature and certainly no voice spreading. In the light of recent work done by several linguists on linking the laryngeal features together and connecting the phonological features with laryngeal gestures, we now consider some of these laryngeal models to see if Kera is best described in terms of tones and VOT separately or if there is a more efficient and helpful model that can bring these apparently separate features together. We have already seen that Bradshaw (1999) combines voicing and tone in one feature, but the model we are looking for needs to be able to cover the varied circumstances in the different dialects.

6.4 Laryngeal feature models

In chapter 5, we considered the development and subsequent loss of tone in different stages of Kera. We saw that historically, Kera probably had a voicing contrast, but no tonal contrast. Then through a process of tonogenesis, three tones developed and voicing was lost. Synchronically, among Kera women, there is still a three-way tonal contrast and no VOT contrast, but in men and women who have moved to town, the tonal contrast is being reduced and the VOT contrast is returning. This is probably due to contact with French.

In this chapter, we are concerned with the features and grammars which can describe each of these stages. We will consider various laryngeal feature models that could be used to describe Kera. Our criteria in choosing between them will be as follows:

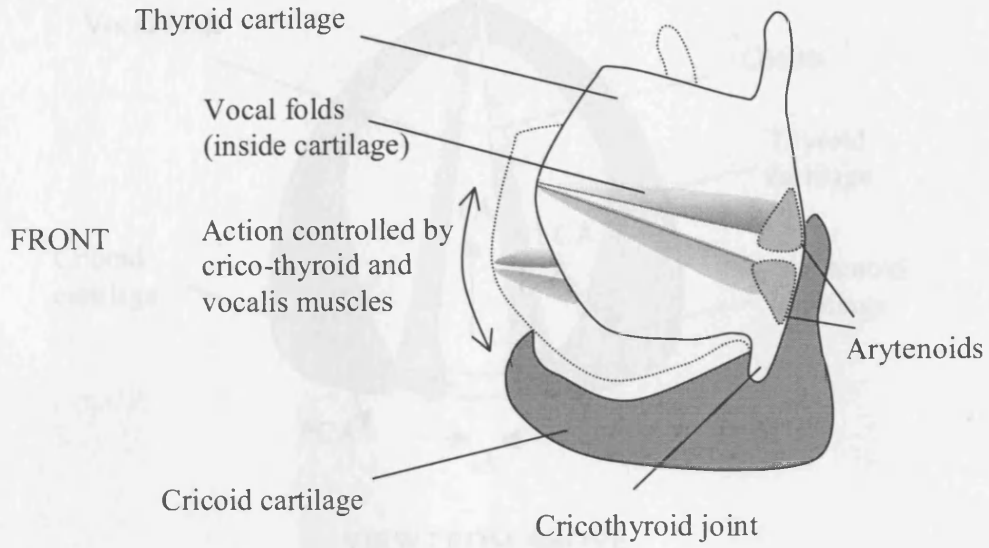
(16) *Criteria for deciding on a laryngeal feature model to describe Kera*
(i). A good model will have to be able to deal with three tones.
(ii). The model should link L tone with [+voice] and H tone with [–voice].
(iii). Because of the differing dialects in Kera, the model should describe how tones and voicing seem connected in some dialects and not others.
(iv). The model should give a reasonable account of the motivation for the changes in dialect, particularly for Village/Town Men moving from a Village grammar to a Village/Town grammar.

This section will begin in §6.4.1 with a description of the laryngeal gestures that are modelled in laryngeal feature models. In §6.4.2, we will consider which model to use. We will eventually settle on a slightly modified form of the Halle and Stevens (1971) model of laryngeal features.

6.4.1 Description of laryngeal gestures

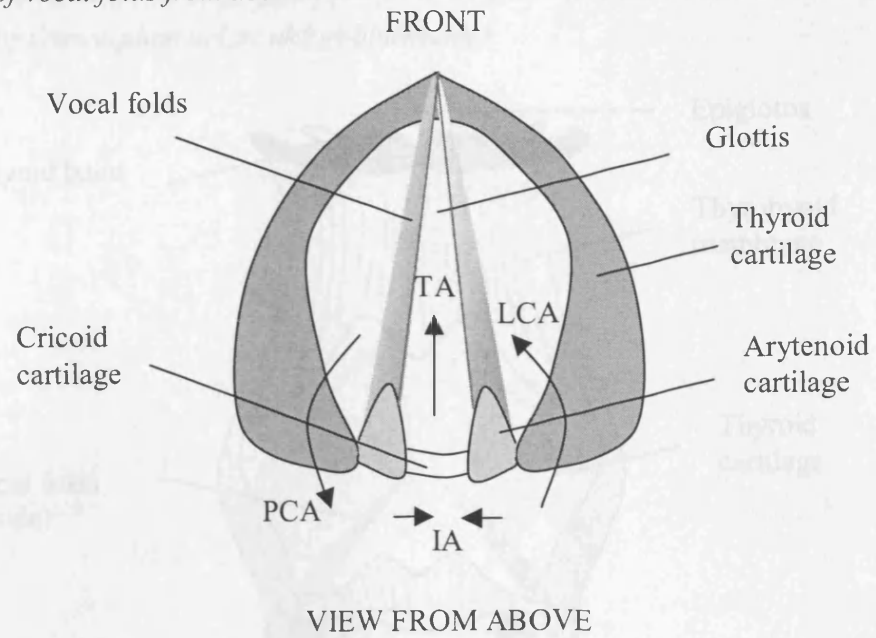
Most models describe changes in tone with references to changes in the length and mass of the vocal folds. The mechanism used to achieve this is the tilting of the thyroid cartilage. The thyroid cartilage can be tilted forwards and backwards with a pivot at the cricothyroid joint. This affects the length and tension of the vocal folds because they are attached to the thyroid cartilage at one end and the cricoid cartilage at the other, via the arytenoids. The cricothyroid muscle is used to lower the thyroid cartilage and the vocalis muscle to raise it. The contraction of the cricothyroid muscle causes greater length and tenseness and this results in a raised pitch. The slackening of this muscle results in decreased stiffness in the vocal folds and the vocal tract walls, and an increased supraglottal volume. This facilitates vocal fold vibration and lowers the fundamental frequency. So this dimension gives the two opposite gestures which Halle and Stevens (1971) labelled as [+Stiff vocal chords] and [+Slack vocal chords].

(17) *Side views of the thyroid cartilage and tilting mechanism*



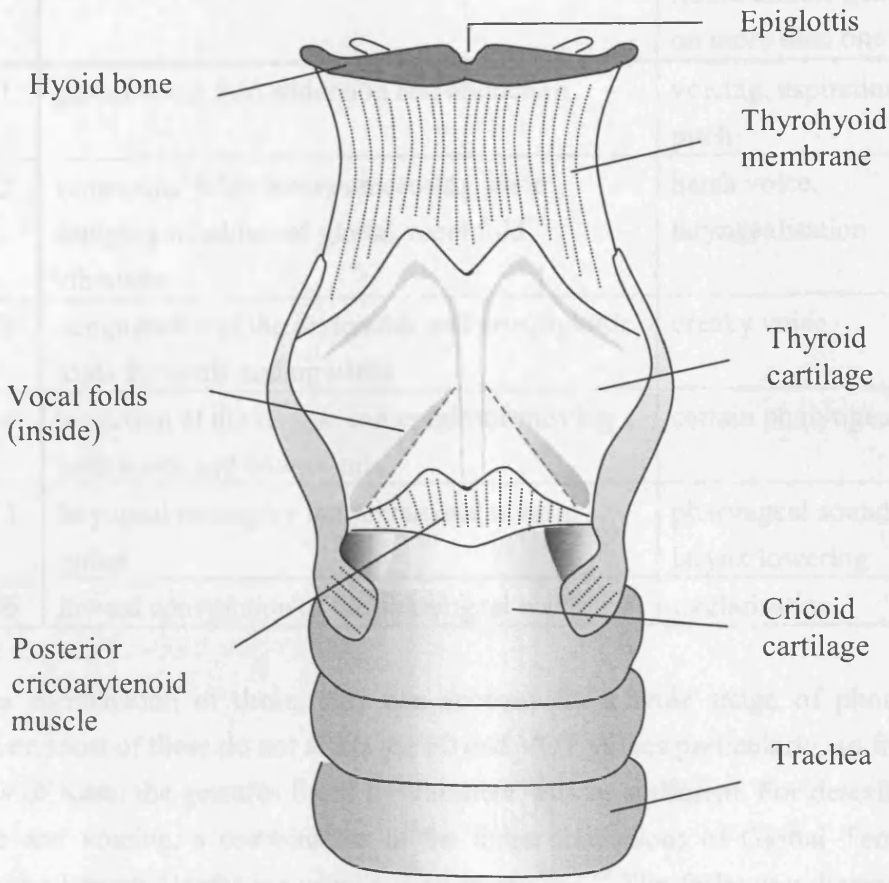
In terms of the grammar, Kera does not need any other laryngeal features, but we will refer to the opening of the glottis as this has a phonetic effect. The opening between the vocal folds can be increased (abduction) or decreased (adduction). To make the glottal gap wider, the posterior cricoarytenoid muscle (PC) is employed. To close the gap, three muscles can be involved: The interarytenoid muscles (IA) close up the arytenoids cartilages, the lateral cricoarytenoid muscle (LCA) rotates the vocal folds towards each other, and the thyroarytenoid muscle (TA) moves the arytenoid cartilages inward. In present day Kera, the VOT values are always positive. This could imply that the glottis always has an open setting. This is not contrastive so phonological features are not required, but if the opening was used in contrasts, Halle and Stevens (1971) would use the features [+Spread glottis] or [+Constricted glottis]. These features will be referred to in some of the models that we will review.

(18) *View of vocal folds from above*



Although the features already described are sufficient to cover the Kera case, some laryngeal models include other features. Vaissière (1997) has selected four major larynx gestures that are involved in changes of voicing, F0 and phonation types. The first is the change in subglottic pressure which is generally used for focus and prominence. We will not be discussing this variable further here. The second is the change in the length and mass of the vocal folds as mentioned above. This gives us the features [Slack v.c.] and [Stiff v.c.]. The third major gesture of Vaissière is the adjustment of the glottis, giving [Spread gl.] and [Constricted gl.]. Finally, the whole larynx can be raised or lowered. By changing the volume of the supraglottic cavities and changing the vocal fold tension, this gesture can also raise and lower F0 and affect the ease of voicing. The larynx can be raised or lowered by the soprahyoid and infrahyoid muscles (for raising and lowering respectively). The hyoid and larynx move together. Raising the larynx causes higher pitch, as the vocal folds tighten and the space above the larynx becomes shorter. Sharp movements up and down can also be used for ejectives and implosives. Support for using [Raised] and [Lowered] as features comes from Ladefoged (1973), Ohala (1978) and Hombert (1978).

(19) *View of thyroid cartilage from the front (based on UCL Phonetics and Linguistics website: http://www.phon.ucl.ac.uk/cgi-bin/wtutor)*



VIEW FROM FRONT

Until recently, there has been a lack of physiological data on larynx behaviour. Edmondson and Esling (2006) have begun to rectify this, and their model involves six 'valves' which describe the six main gestures of the larynx.

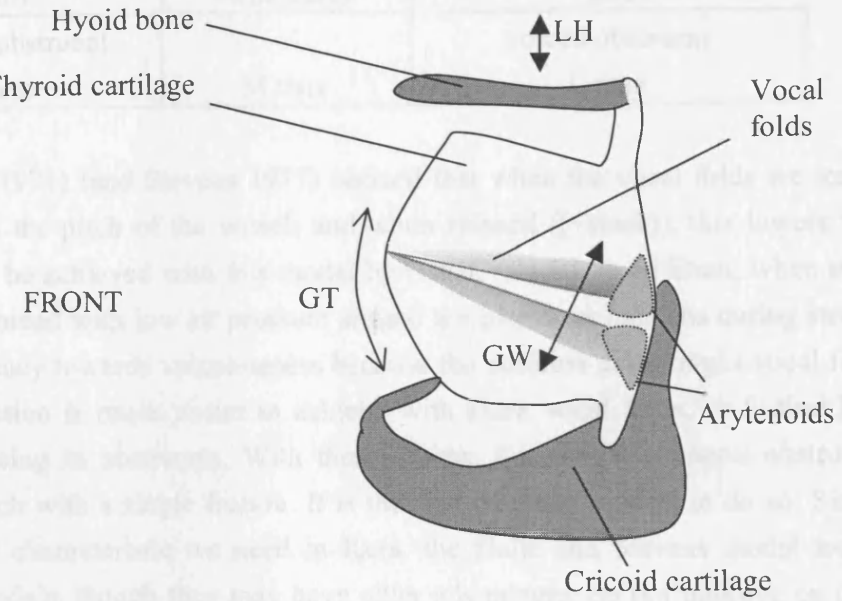
(20) *Description of valves and effects, summarised from Edmondson and Esling (2006)*

Valve	Description	Rough guide of effects (these effects generally rely on more than one valve)
Valve 1	glottal vocal fold adduction and abduction	voicing, aspiration and pitch
Valve 2	ventricular folds incursion causing some damping of adducted glottal vocal fold vibration	harsh voice, laryngealisation
Valve 3	compression of the arytenoids and aryepiglottic folds forwards and upwards	creaky voice
Valve 4	retraction of the tongue and epiglottis moving backwards and downwards	certain pharyngeal sounds
Valve 5	laryngeal raising by the suprahyoid muscle group	pharyngeal sounds with larynx lowering
Valve 6	inward constriction of the pharyngeal walls	uvularisation

With a combination of these, they can account for a wide range of phonation types. However, most of these do not affect the F0 and VOT values particularly, so from the point of view of Kera, the gestures listed by Vaissière will be sufficient. For describing changes in tone and voicing, a combination of the three dimensions of Glottal Tension, Glottal Width and Larynx Height are usually used in models.[12] The following diagram shows the three dimensions combined.

[12] These terms come from the Avery and Idsardi (2001) model (see §6.4.2.5).

(21) *Three gestures of the larynx*



6.4.2 Laryngeal Features and models

We will now look at some of the main models that have been proposed for tone languages. In reviewing the models, we will keep in mind the criteria in (16) for evaluating how well the model deals with Kera. Particularly, we need a model that gives insights into the connection between tone and voicing (Haudricourt 1954; Leben 1973; Goldsmith 1976; Hombert et al 1979; Yip 1980; Peng 1992; Bradshaw 1999).

Various attempts have been made to match up the articulatory gestures associated with the larynx to the phonological categories of voicing, tone and various phonation types. Vaissière (1997) and Yi Xu (p.c.) point out that larynx functions are difficult to model because several movements have effects on the same features. However, I believe that models which involve features that bear a resemblance to laryngeal gestures can be useful.

6.4.2.1 Halle and Stevens (1971)

The model of Halle and Stevens (1971) was the first model to seriously describe the link between tone and voicing, which is our second criteria in (16). The basic framework of their model for the features [±stiff vocal chords] and [±slack vocal chords] is shown in (22). Note that while Halle and Stevens opted for binary features, I will be treating them as unary, i.e. [Stiff] and [Slack]. My reasoning for this is that only positive values for these features are active in Kera, and in modern feature theory, if no negative values are active, features are usually considered to be unary. However nothing key in this thesis hangs on this argument.

(22) *Halle and Stevens (1971), features [±stiff] and [±slack]*

+ stiff	-stiff,-slack	+ slack
voiceless obstruent H tone	M tone	voiced obstruent L tone

Halle and Stevens (1971) (and Stevens 1977) noticed that when the vocal folds are tense ([+stiff]), this raises the pitch of the vowel; and when relaxed ([+slack]), this lowers the pitch. Mid tone can be achieved with this model by [-stiff, -slack]. In addition, when stiff vocal folds are combined with low air pressure around the glottis, as happens during stops, then there is a tendancy towards voicelessness because the stiffness discourages vocal fold vibration. The vibration is much easier to achieve with slack vocal folds, so [+slack] is associated with voicing in obstruents. With these claims, this model connects obstruent voicing and low pitch with a single feature. It is the first of many models to do so. Since this is the essential characteristic we need in Kera, the Halle and Stevens model looks promising. Later models, though they may have other advantages, do not improve on this basic insight, so I will conclude that the Halle and Stevens model is sufficient for Kera.

Halle and Stevens also introduced another pair of laryngeal features: [constricted] and [spread]. Aspiration and breathiness is linked to the spreading of the glottis and a constricted glottis is connected to glottalisation. Combining all of these features, we get the following settings:

(23) *Combining laryngeal features in Halle and Stevens (1971) model*

	+ stiff	-stiff,-slack	+ slack
+ spread	aspirated, voiceless C	voiceless V or C	breathy, voiced V or C
- spread,-constr	voiceless, H	M	voiced, L
+ constr	glottalised	implosive	glottalised, creaky

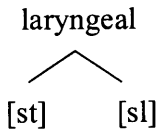
6.4.2.2 Yip (1980), Bao (1990), Duanmu (1990)

Halle and Stevens (1971) model was innovative in the way it linked voicing, tone and phonation types in the same laryngeal features. It has been useful for describing tonogenesis and languages which have a clear relationship between voicing and tone. But one particular drawback with this model has been noted. Only a three-tone contrast is possible. This is enough for Kera, but some languages have four level tones. For this reason, Yip (1980), and later Bao (1990) and Duanmu (1990) realised that the system needed refining. They wished to address the fact that only three tones are allowed for by Halle and Stevens, and also that in four-tone systems which are common in Asian languages, there appears to be a pairing off of tones into two binary dimensions which can

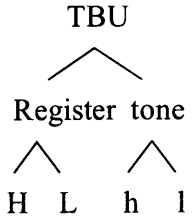
be named register and tone. Duanmu (1990) summarises some of the models up to the time of his model. All of these focus on modelling tone languages:

(24) *Various models for tone languages as described by Duanmu (1990)*

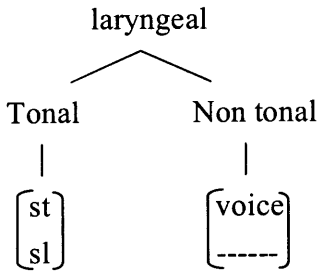
Halle and Stevens (1971)



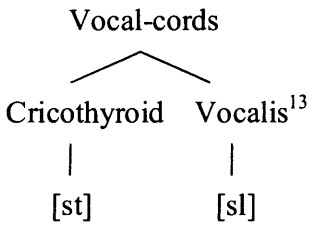
Yip (1980)



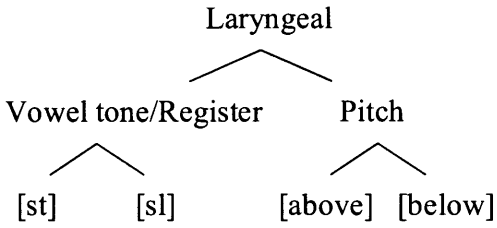
Kingston and Solnit (1988)



Bao 1990



Duanmu 1990



Bao attempts to associate muscles with the two features from Halle and Stevens, but he still has a problem with 4-tone languages, as do Kingston and Solnit. Essentially, one dimension is not enough to cover the necessary tone facts. Yip addresses this with a binary contrast of 'register' and a binary contrast of 'tone'. This gives the possibility of four tones. Duanmu also has two dimensions ('register' and 'pitch'), but Duanmu's model generates more possible combinations because he allows every combination of three registers and three pitches, giving 9 options.

[13] This link of the cricothyroid to stiff and the vocalis to slack is preserved in the model of Avery and Idsardi (2001). There is no reason why it cannot be applied to Halle and Stevens (1971) model too.

(25) *Diagram from Yip (2002) of Duanmu (1990) model*

	above	below
+stiff, - slack	+ - -	- - +
-stiff, -slack	+ - -	- - +
-stiff, +slack	+ - -	- - +

Duanmu tentatively labels the vowel tone node as linked to the vocalis muscle and the pitch as linked to the cricothyroid. He claims this connection again in Duanmu (1999). The problem with this claim is that many linguists see the cricothyroid and the vocalis muscles as working in tandem on the same dimension, with one muscle undoing the effect of the other. But if we leave aside Duanmu's claims concerning the muscles involved, we are left with a system that can describe an impressive list of tone languages. Duanmu allows for other dimensions as extra nodes may also be needed under the laryngeal nodes for effects like ATR and aspiration. He suggests Tongue Root and Arytenoids nodes respectively. The label 'arytenoids' is really another way of describing glottal width.

Duanmu (1990) lists several criteria for checking models with phenomena that should be explainable by the model. He claims that his model can cover them all.

(26) *Duanmu (1990) list of factors to be included in a good laryngeal model*

a) The minor pitch perturbation following voicing. e.g. in English (Hombert 1978)

b) Tonogenesis and the correlation between tone and voicing (Haudricourt 1954, Bradshaw 1999)

c) Upper and Lower registers in Chinese languages and depressor Consonants (lowering tone in Bantu languages)

d) The blocking of H and L tone spreading by voicing and voicelessness respectively (Hyman and Schuh 1974)

e) Changes in vowel quality or height when onset voicing is lost

f) Tones and Register spreading independently (Yip 1980, Bao 1990)

g) Upper and Lower tones overlapping in pitch

h) 5 tone languages (reportedly Black Miao and Tauhuo Yao)

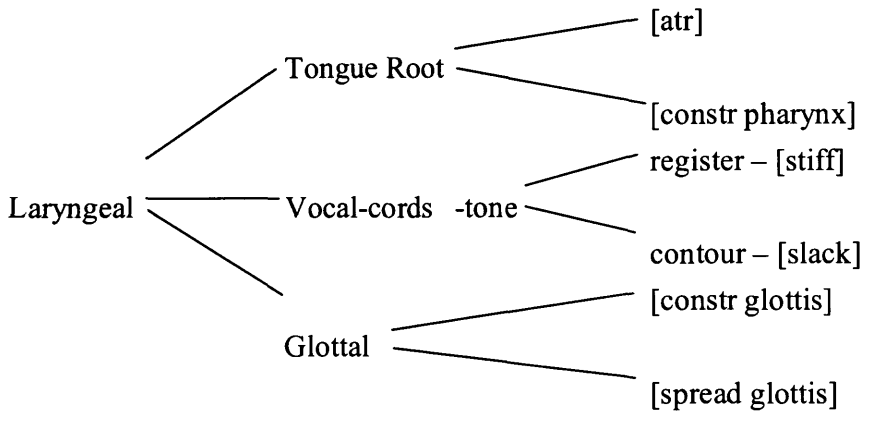
i) Tones falling into natural classes so H links to M' and M links to L while in other ways H links to M and M' links to L.

If Duanmu (1990) can cover all of these, the question is why we need consider any other model. Duanmu admits that his concern is only tone, but it would be good if the model also looked beyond tone into voicing, aspiration and phonation types. Also, it is unclear what the terms [above] and [below] actually mean. We would like to link these to articulatory movements if possible. Duanmu's model has been criticised for predicting 9 tones and 81 contour tones. In response to this, he has argued that maybe only one of the nodes is concerned with tone and the other with phonation types, but if this is the case, then he only has 3 tones and we are back where we started.

6.4.2.3 Bao (1999)

Bao (1999) has a slightly different version of this model again.

(27) *Bao (1999)*



This model effectively has glottal width and glottal tension nodes. Bao claims that a combination of [+stiff, +slack] is possible. Many linguists would argue against that. But essentially, the models of Yip, Duanmu and Bao have much in common. They are all helpful models particularly for the languages they were originally intended for, i.e. Asian languages with 4 tones.

These models do have something to contribute for languages with four tones, but if we return to our criteria in (16) for deciding on a good model for Kera, we see that all of the models discussed so far can cope with the 3 tones of Kera. The models of Yip, Duanmu and Bao do not give any advantages above the Halle and Stevens (1971) model for describing how tones and voicing are linked, particularly in a 3-tone language.

6.4.2.4 Models including [voice]

Other linguists who have been less concerned with tone and more concerned with voicing and phonation types have offered a variety of models. Lombardi (1991) adds

[Voiced] as a feature alongside [Constricted] and [Spread]. But although this accounts for voicing changes, it still does not attempt to cover tone. There is another reason for rejecting this solution and other similar models which combine [Voice] with laryngeal features. [Voice] is a feature which is concerned with the production results. It can be measured on a spectrogram, yet it is not concerned with the manner with which the effect is achieved. [Constricted] and [Spread] on the other hand are concerned with the gestures of the larynx rather than the production output. The types of feature are mixed here, and in addition, the raising and lowering of the larynx has an effect on voicing, so the features overlap in a way that can't be defined. It would be better to restrict ourselves either to production features such as [Voice] and [Aspiration], or to articulatory gestures such as [Stiff] and [Spread]. This does not mean that we aim or even desire to cover every laryngeal gesture in our phonological model. Not all gestures are relevant to the phonological grammar, and a detailed phonetic description would not help in clarifying the phonology, but it should be possible to find gestural features that can model the phonology without that much detail.

The views of Bradshaw (1999, 2003) have already been mentioned several times in this thesis, so a quick summary will suffice here. Her model involves a monovalent feature [L/voice] which can associate on the segmental level to either the laryngeal node of the consonant or on the prosodic level to the mora. When this feature is associated to the laryngeal node, the segment is phonologically voiced. When it is associated to a mora, the corresponding vowel has L tone. When it is associated to both, consonant-tone interaction takes place. Bradshaw does not say that the feature is always linked to both the consonant and the vowel, so her model is effectively quite close to the Halle and Stevens (1971) model in their use of the feature [Slack], although she does not acknowledge this. The real difference between Bradshaw and Halle and Stevens is that Bradshaw does not allow for the same kind of interaction between voicelessness and H tone. Halle and Stevens can account for 'raiser' effects with [Stiff], but Bradshaw has to account for everything in terms of [L/voice].[14] On the other hand, depressor consonants are attested in many more languages than raisers, so Bradshaw's research is insightful for many languages. For example in the Chadic language Mulwi (Tourneux 1978), both H and L tones can follow voiceless obstruents, but word-initial depressor consonants are followed by L tones. The [L/voice] feature appears active but there is no [H/voiceless] equivalent.

(28)	bìzì	'spend the year'	bìzí	'apply pressure'
	kì	'flow'	kí	'accompany'

[14] Her model appears to be flexible as to whether sonorants and implosives are included in the [L/voice] feature or not.

So Bradshaw (1999) covers asymmetry well, but this model could be a problem for Kera with apparent depressors and raisers plus a neutral group. The variation across dialects in Kera would also be a challenge for the theory as it would require spreading between the segmental and prosodic levels. We will therefore not be using Bradshaw's model for the analysis of Kera.

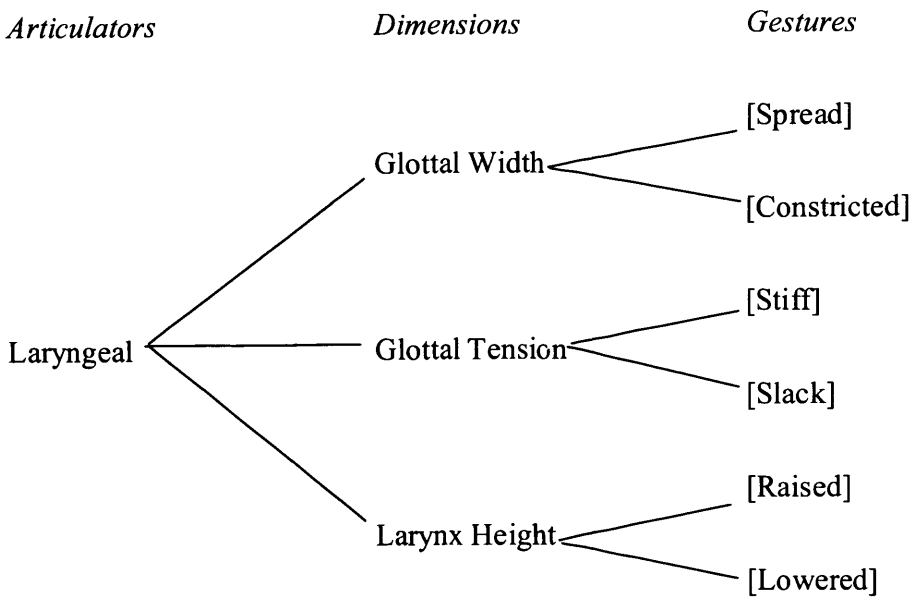
Before assuming that the variables should be articulatory, it should be noted that not all phonologists agree about how closely phonological features should be linked to laryngeal gestures. A lot of good analysis has been done using the features [Voice], H, M, L and these features do not make a direct reference to the articulation. Some phoneticians also believe that the articulatory processes are too complicated to be successfully lined up with one phonological feature.

There is also a difference of opinion on whether voicing, short lag and aspiration are all part of one continuum or whether they require different mechanisms. Lisker and Abramson (1964) suggest that long VOT is affected by the duration of the constriction, while Halle and Stevens imply one dimension of [±spread glottis]. Vaissière (1997) notes that the duration of the constriction, the abduction of the vocal folds and other factors are also involved in aspiration, but that the use of various muscles can depend on whether aspiration is contrastive. For Kera, aspiration does not seem to be much in focus, and VOT measurements provide a good comparison of obstruents. For this reason, in my analysis, I will treat voicing, short VOT and long VOT as points on a continuum. This is a simplification that works well for Kera.

6.4.2.5 Avery and Idsardi (2001, forthcoming)

We will look briefly at one more model which superficially follows along similar lines to Duanmu's (1999) model but with different labels. Avery and Idsardi (2001) replace Duanmu's Vowel/Register node by the Glottal Tension dimension, Pitch is replaced by Larynx Height and the Arytenoids node is replaced by Glottal Width.

(29) *Avery and Idsardi (2001)*



The following table drawn up by Avery and Idsardi lays out the dimensions and gestures of their theory with the muscles involved and the phonetic effects of each.

(30) *Avery and Idsardi dimension effects*

Dimension	Feature	Muscle Groups	Phonetic Effects
Glottal Tension	[Slack]	vocalis	lower pitch facilitates voicing
	[Stiff]	cricothyroid	higher pitch inhibits voicing
Glottal Width	[Spread]	posterior cricoarytenoid	aspiration (breathiness with [Slack])
	[Constricted]	interarytenoid lateral cricoarytenoid thyroarytenoid	Glottalization ejectives implosives
Larynx Height	[Raised]	suprahyoid muscles	higher pitch ejectives
	[lowered]	sternohyoid, omohyoid ("strap muscles")	lower pitch implosives

In the Avery and Idsardi model, each of the dimensions can be realised by two privative, antagonistic 'gestures' which are either present or absent. Only one gesture can be active at any time within each dimension. The model assumes economy, so phonological representations are minimally specified in terms of the dimensions. Where possible, the model aims at a contrast of the type Ø / marked. So for example, French and English would be modelled as follows:

(31) *Avery and Idsardi model of French and English*

French:	GT	Ø	Ø	English:	Ø	GW	Ø
	|					|	
	[Slack]					[Spread]	

There are two stages to the model. Firstly the contrasting dimensions are set up, so for French this would simply be GT, Ø. Then the phonetic representations are added in a process which they call 'completion'. Dimension nodes are completed with a 'gesture', the defaults being [Slack], [Spread] and [Raised], although in certain situations, the antagonistic gesture may be chosen. Notice that the first two dimensions are essentially the same as the Halle and Stevens model, but the model is different because Avery and Idsardi do not allow the two gestures under one dimension to both be used for a tonal contrast. So they would not allow a grammar that used [Slack] in one of the contrasts and then [Stiff] in another. For most languages this is insightful. It explains the many languages that have either a voiced/voiceless contrast (with voiceless unmarked as in French) or an aspirated/non-aspirated contrast (with non-aspirated unmarked as in English), while two-way contrasts between voiced and aspirated are arguably unattested. Equally, 2-tone languages do not generally have L tone and H tone where both are marked. However, this limits the possibilities for generating tone on the GT scale. Avery and Idsardi resolve this limitation by claiming that Larynx Height also affects tone. With this, they can deal with 4-tone languages.

(32) *A selection of grammars for tone languages based on Avery and Idsardi (2001)*

A typical set-up for a 2-tone language would be as shown in (31) for French.

a.

L	M/H	
GT	Ø	Ø
|		
[Slack]		

Although not stated by Avery and Idsardi, they would presumably deal with a H marked language in the following way:

b.

L/M		H
Ø	Ø	LH
		|
		[Raised]

As the model is based on a marked and non-marked contrast, it probably could not cover a language where both tones are marked. Although Idsardi (p.c.) does allow for both GT [slack] and LH [raised] to be active in Xhosa. The GT is associated with the 'depressor' consonants and then spreads onto the following vowel producing a rising tone on that vowel instead of the high tone that follows a 'non-depressor'.

For a 3-tone language such as Nupe (Smith 1967, Yip 2002), a typical arrangement would be:

c.

L	M	H
GT	Ø	LH
|		|
[Slack]		[Raised]

For 4-tones in languages such as Mambila (Connell 2000, Yip 2002), a combination of GT and LH is needed for one contrast:

d.

L	M-	M	H
GT	GT+LH	Ø	LH
|	|		|
[Slack]	[Slack]		[Raised]
	[Raised]		

Although this diagram for 4-tone languages looks quite different from earlier models that we looked at, it is essentially claiming a similar arrangement to Yip (1980), i.e. 2 features each giving a binary choice. It would seem that for 4-tone languages, a model with two features each with a binary choice works best.

Avery and Idsardi's model could be criticised like Duanmu's model as being too powerful. They therefore add several restrictions concerning which gestures can co-occur. Space does not permit us to look at these. In some cases their restrictions make good sense

typologically, but there are questions about others as to whether they are really universal. Here, I am not concerned with these details, but with the general concept of the model.

Several languages have been analysed using this model and details can be seen in Avery and Idsardi (2001), Iverson and Salmons (2003) and Jensen and Stong-Jensen (2005). For most languages it works well, but for Kera and some other Chadic languages there are problems with the restrictions on the combinations of gestures. In languages with a 3-way contrast, I question their view that [Stiff] never contrasts with [Slack]. In Chadic languages such as Bade (Schack Tang, 2006), there are depressor and raiser consonants and the L and H tones appear to be part of a symmetrical pattern, with both spreading in the same way. It is hard to claim that one of these is unmarked or that the L tone comes from a different dimension to the H tone. Kera equally seems to show a certain amount of symmetry between the behaviour of L tone and H tone at least historically. If we use the Avery and Idsardi model, we have to claim that L and voicing come from the GT dimension while H and long VOT come from the Laryngeal Height dimension. This is possible, but it does not seem intuitive as the motivation for symmetry is lost.

This model has much to offer in terms of typology and in the connection between articulation and phonological and phonetic realisations, but at the moment the restrictions seem too restrictive. The model would be applicable to more languages if these restrictions were dealt with as violable constraints, although this might again make the model too powerful, and is not a direction suggested by the designers of the model.

For this thesis, we need to focus on a model that gives an account for the close connections between tone and consonantal voice, preferably with the same features being used for both. The models of Yip, Duanmu, Bao and Avery and Idsardi all do this, and each has insights to offer for an understanding of laryngeal features, but for the analysis of Kera, they do not add anything to the Halle and Stevens (1971) model. Therefore, I will now adopt the Halle and Stevens model with minor alterations to describe Kera. In the next section we will consider the grammars for each diachronic stage and each synchronic dialect of Kera.

6.5 Grammar of Kera diachronic and synchronic stages

The grammars that will be presented in this section will all include the features [Slack] and [Stiff] associated with consonants. The effect of these features on consonants will be to change the VOT values. The features [Slack] and [Stiff] will also be associated with vowels, changing the F0 value. We will aim at a minimal use of features, so contrasts will be described in terms of the presence or absence of a feature rather than as positive and negative values of the feature. The historical changes that take place in moving from one grammar to the next will involve either the movement of a feature (spreading or shifting),

or the addition or loss of a feature. An important part of the account is the minimum amount of change that is needed to move from one grammar to the next. For the account to be credible, it needs to describe changes that are both motivated and uncomplicated.

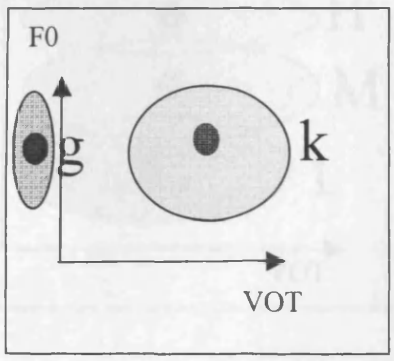
Throughout this section, small copies of the schematic and data graphs that were first shown in chapter 5 (§5.4 and §5.6.2) will be repeated here to clarify the differences between the stages.

6.5.1 Diachronic stages of Kera development

(i) Proto-Chadic

We discussed in chapter 5 (§5.4) how Proto-Chadic reconstructions (Jungraithmayr and Shimizu 1981, Stolbova 1996, 2005) show voicing contrasts (represented here as g and k) but no tonal contrast. Using the features [Slack] and [Stiff], we will represent the voiced contrast with [Slack] placed on the first consonant, which leads to that consonant being voiced.

(33) *Proto-Chadic grammar*



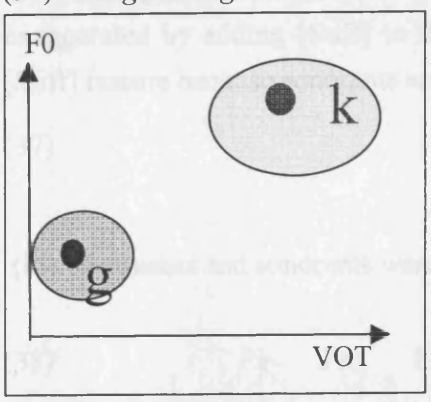
ba pa
|
Slack

The contrast could equally be between no feature for the first contrast and [Stiff] for the second. We cannot now verify which grammar is correct. But the account using [Stiff] would make the subsequent story harder as it seems to be the voicing that motivates tonogenesis. So we will assume that there was voicing which was represented by a feature [Slack] on the first contrast onset.

(ii) Tonogenesis

As a tonal contrast developed, not only was there a voicing contrast, but the tones also differed across contrasting pairs. This is analysed as [Slack] spreading onto the vowel in the first contrast, giving low tone, but keeping voicing on the onset.

(34) *Tonogenesis grammar*

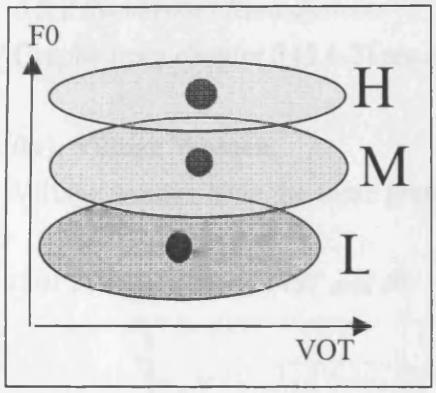


bà pa
Slack

(iii). Three-tone language

At some point three tones developed and voicing was lost.

(35) *3-tone grammar*



Pà Pa Pá
Slack Stiff

At this stage, the spreading of [Slack] leads to a disassociation of [Slack] from the consonant. The consonant lost voicing, and the voicing/F0 connection was lost. In Kera, three tones developed rather than two, with a 3-way contrast: L, M, H. As we suggested in chapter 5, it could be that the third tone came from the sonorants. If so, then the grammar may have gone through the following stages.

(i) A middle tone for sonorant words was introduced. Sonorants may have initially been grouped with 'H tone' because they did not carry the feature [Slack]. But then because of the delayed peak following sonorants, they were perceived as being associated with 'M tone' by subsequent generations.

(36) bà ma pa
Slack

(ii) Voicing was lost and the feature shifted onto the vowel. The tone difference is exaggerated by adding [Stiff] to the 'H tone' contrast. Sonorants were not followed by a [Stiff] feature because sonorants are produced with slack vocal folds.

(37)

Pà	ma	Pá
Slack		Stiff

(iii) Obstruents and sonorants were permitted with all three tones

(38)

Pà	Pa	Pá	mà	ma	má
Slack		Stiff	Slack		Stiff

We cannot be sure that this is the correct account of the changes that took place, but it is a plausible way of arriving at the grammar in (35).

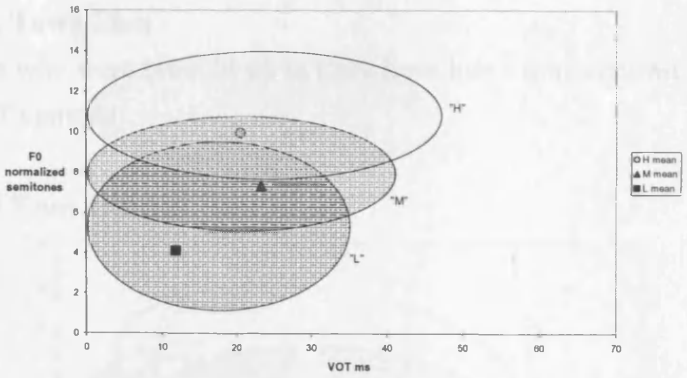
6.5.2 Synchronic Kera dialects

Graphs from chapter 5 (5.6.2) are repeated here for reference.

(iv). Village Women

Village women have the same grammar as just described.

(39) *Village Women VOT and F0*



The VOT value is varied within a range. This implies that the glottis opening is free to vary (indicated with P)

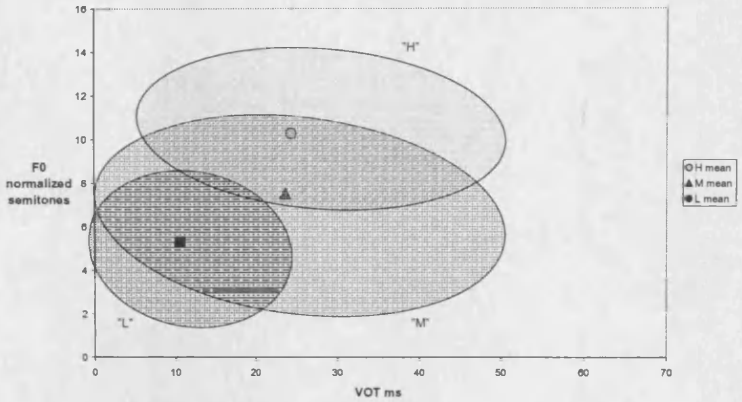
(40)

Pà	Pa	Pá
Slack		Stiff

(v). Village/Town

Village/Town Men show a pattern where the first contrast has a short VOT and the other contrasts have a longer VOT. French is causing a big increase in the use of VOT as an enhancing cue, but the F0 3-way contrast is still preserved.

(41) *Village/Town Men VOT and F0*



[Slack] now spreads onto the onset in the L tone contrast. This isn't realised as true voicing because the glottis is kept at least partially open, but the VOT is short.

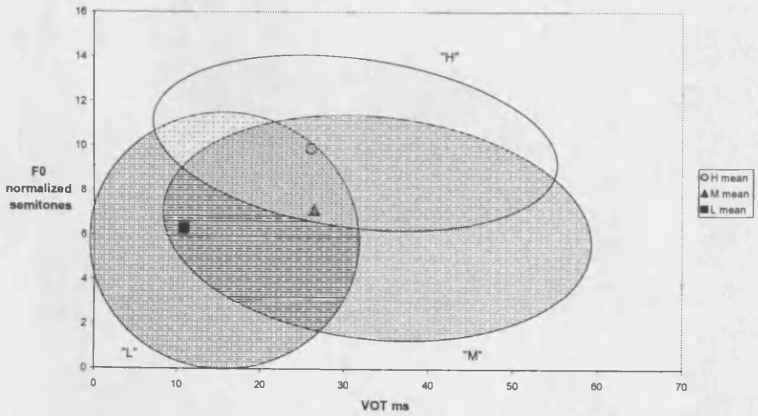
(42) bà Pa Pá

Slack Stiff

(vi). Town Men

Men who were brought up in town have lost a tone contrast and they are replacing it with a VOT contrast.

(43) *Town Men VOT and F0*



The tonal contrast is shown by Ø versus [Stiff] on vowels. The VOT contrast is shown by Ø versus [Slack] on consonants. The only change to the previous grammar is that the feature [Slack] has now reverted to being only on the onset. So the first two contrasts have the same tone as there is no feature associated with either of these vowels.

(44)

ba	Pa	Pá
|		|
Slack		Stiff

In chapter 5, we also looked at Town Women, who have moved even further towards loss of all tones, but as they have not yet changed their grammar from that of town men, we will not discuss them further in this chapter except to say that they appear to be moving towards the grammar:

(45)

ba	Pa
|	
Slack	

In summary, the grammars discussed so far are in (46). Note that all synchronic dialects have a 3-way contrast, but they differ in whether the contrast is located on C, V or both.

(46) *Summary of Kera grammars*

	Contrasts (analysis)			Phonetic	Contrasts
Original	ba | [Slack]	pa			ba pa
Tonogenesis	bà |/ [Slack]	pa			bà pa
Village (= 3 tones)	Pà | [Slack]	Pa	Pá | [Stiff]	VOT allowed to vary	Pà Pa Pá
Village/town	bà |\ [Slack]	Pa	Pá | [Stiff]	In H and M, VOT varies	bà Pa Pá
Town	ba | [Slack]	Pa	Pá | [Stiff]	In H and M, VOT varies	ba Pa Pá

b implies short VOT, p implies long VOT. P means that the VOT shows variation between 0-60 ms.

The variation in VOT could be brought about by changing the opening of the glottis. It could also be affected by the timing of the closure outside of the larynx. In modern day Kera, there is no true voicing, so the variation in VOT is between 0 and 60 ms.

One immediate observation that can be made from these results is that apparently, sound change is not always unidirectional. The town speakers have almost returned to the starting point of the Proto-Chadic grammar.

There is no change in the number of contrasts (except possibly the town women) and it seems that there is no change in the lexicon between village and town. The changes that do take place involve the association of [Slack] with the consonant or vowel or both. This can be modelled in Optimality Theory with minor adjustments in constraint ranking.

6.5.3 OT analysis of tone with laryngeal features

The table below shows the synchronic differences and the undominated constraints which are needed to model them.

(47)

	Contrasts			Undominated Constraints
Village	Pà | [Slack]	Pa	Pá | [Stiff]	*C *C | | Sl St
Village/town	bà |/ [Slack]	Pa	Pá | [Stiff]	AGREE [Sl] *C | St
Town	ba | [Slack]	Pa	Pá | [Stiff]	*V *C *C V | | | | Sl St Sl St
French	ba | [Slack]	pa		*V *St | Sl

Most of the constraints above are clear in meaning, but AGREE [Sl] needs to be defined.

AGREE [Sl]: If one segment is associated with the feature [Slack], all other segments of the syllable must be associated with that feature.

From this we can deduce the ranking of constraints at each stage. Constraints which change ranking are indicated in bold:

(48)

Village: *C (St) , *C V, (Sl St) *C (Sl) » **AGREE [Sl]**, ***V** (**Sl**) , *St

Village/Town: *C (St) , *C V, (Sl St) **AGREE [Sl]** , » ***C,** (**Sl**) ***V** (**Sl**) , *St

Town: *C (St) , *C V, (Sl St) ***V** (**Sl**) » **AGREE [Sl]**, ***C** (**Sl**) , *St

The only constraints that move are the [Slack] constraints, so if we examine the relationship between these, we get:

(49)

Village: *C (Sl) » AGREE [Sl], *V (Sl)

Village/Town: AGREE [Sl] » *C, (Sl) *V (Sl)

Town: *V (Sl) » AGREE [Sl], *C (Sl)

This is typologically interesting because we have all the possible combinations of these constraints barring the ranking that does not allow [Slack] on either C or V.

6.6. Issues raised

There are a couple of issues which still need to be addressed. The first is how we deal with M tone and the second is what happens at foot level.

6.6.1 The reanalysis of M tone

In chapter 4, we tried to treat M tone as the default tone rather than assuming an underlying /M/. But this approach gives us some challenges. Firstly, we need to note that SPECIFY is violated if M is default as not all tones will be specified. This would not be a problem if DEP F is ranked above SPECIFY. For most of this thesis we have treated both these constraints as undominated. So a reranking of these two constraints would be necessary, but this would not be a problem.

Another problem is that if we remove /M/ as an underlying form, we need the [Stiff] and [Slack] features to be associated with specific feet in the lexicon entry. Otherwise, we cannot explain how we have both MH and HM. If all we know is that there is a H tone somewhere in the word, we can tell which segments will be affected by it within the foot, but not which foot to associate it with. So the features need to be anchored to feet.[15] In roots then, H is associated to feet in the lexicon and therefore association lines are lexical and changing them violates a faithfulness constraint. This means that we would need a grammar such as: ROOTFAITH (*ASSOC) »AGREE H » *ASSOC. This means that H will not spread in roots, but it will in suffixes. It also explains the failure of the suffix to spread even within the foot in inalienable nouns (for example *mīrú:* 'his wife').

For verbs, there is no problem concerning M tone except for about four verbs which have a non-altering M tone. One of these is known to be a loan. I suggest that all M verbs are loans and that the tones do not change because these processes are no longer productive.

So with the caveat that lexical entries include some association of the tone with the foot, we can avoid having an underlying /M/ tone. This is in keeping with the treatment of syllabic nasals which we discussed in chapter 1, where the syllabicity also has to be marked in the lexicon.

6.6.2 Extending the analysis to the foot

In (47), we looked at the tone analysis in terms of the [Stiff] and [Slack] features associated with segments at the level of the syllable. We can now predict the patterns of tone and VOT that we would expect to occur on disyllabic feet. (50) shows the predictions, with b

[15] If we do not wish to have features associated with feet in the lexicon then we must maintain an underlying /M/ tone. In laryngeal feature terms, this could be achieved if we return to the binary features of Halle and Stevens (1971) where [-stiff, -slack] can be underlying. With unary features the only option is assigning features to feet in the lexicon.

indicating a short VOT, p indicating a long VOT and P indicating a wide range of VOTs. The reasons for these predictions will be explained below.

(50)	'L'	'M'	'H'
Village:	P ə̀ b à Sl	P ə P a	P ə́ p á St
Village/Town:	b ə̀ b à Sl	P ə P a	P ə́ p á St
Town:	b ə P a Sl	P ə P a	P ə́ p á St

Consider first the Village foot[16]. In the 'L' and 'H' contrasts, the final vowel is associated with a feature (in parallel with (47)). We assume that the head vowel carries the feature and that it spreads back to the first vowel (given that tones apparently spread in disyllabic feet). We also assume that vowel-to-vowel spreading includes the intervening consonant. It does not however spread all the way to the first consonant. For the Village/Town dialect, the 'M' and 'H' contrasts are the same as for the Village. For the 'L' contrast, the feature spreads to cover the whole syllable in (47), so now we assume it covers the whole foot. For the Town dialect, the feature in the first contrast is associated only with the onset in the syllable, so we assume that it will not spread in the disyllabic foot either and that the feature will associate with segments only at the left edge of the foot. We could equally predict that the feature would only associate with the onset of the head syllable, but this is not what happens in Kera. This fact will be important in the discussion at the end of this chapter concerning an alternative analysis.

In (51) we will see if these predictions are correct by comparing disyllabic feet in natural speech with an average of 30 tokens measured in each category. We will focus on the [Slack] contrast as this changes between the groups. The [Slack] contrast is shown in the first two bars of each graph (one bar for each syllable). Look at the first two bars in the Village F0 graph. These give the F0 values for the two syllables in the disyllabic feet with so called 'L' tone. We can see that for the Village Women, the two F0 values are indeed L. The first isn't quite as low as the second implying that the target is towards the end of the

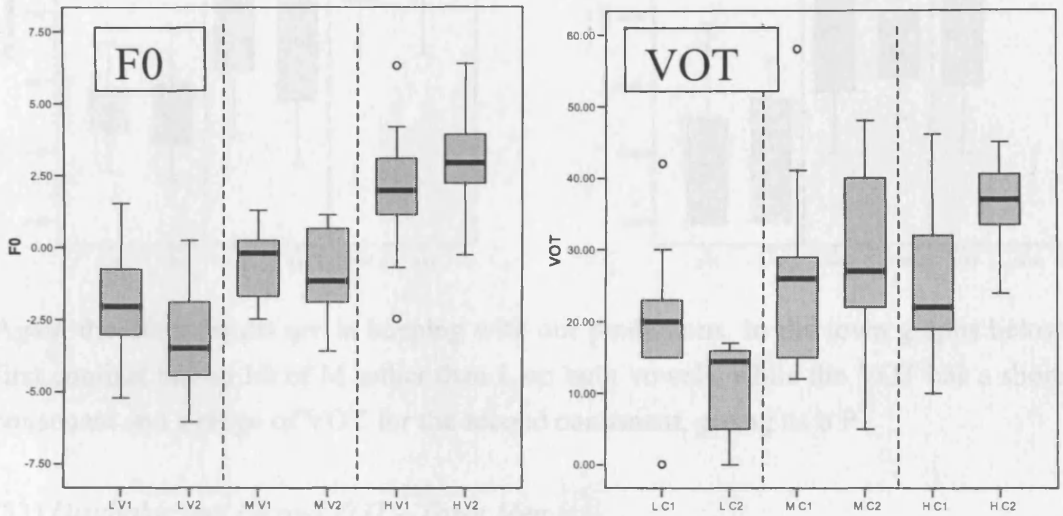
[16] In all of these cases, the foot is assumed to be a well-formed Kera foot. This means that the second syllable must be heavy. This is not indicated in the examples above for the sake of simplicity but it is assumed.

foot and is not attained completely until the second vowel. Now look at the VOT graph. The VOT value of the first consonant in the first contrast is at a medium height, in keeping with the P that we expect[17], whereas the second consonant has a short VOT, in keeping with b.

(51) *Disyllabic feet F0 and VOT – Village Women*

normalized F0: VOT:

ə̀ à, ə a, ə́ á P b, P P, P p



Although not discussed in detail here, we can see that the other bars are also situated in line with our predictions.

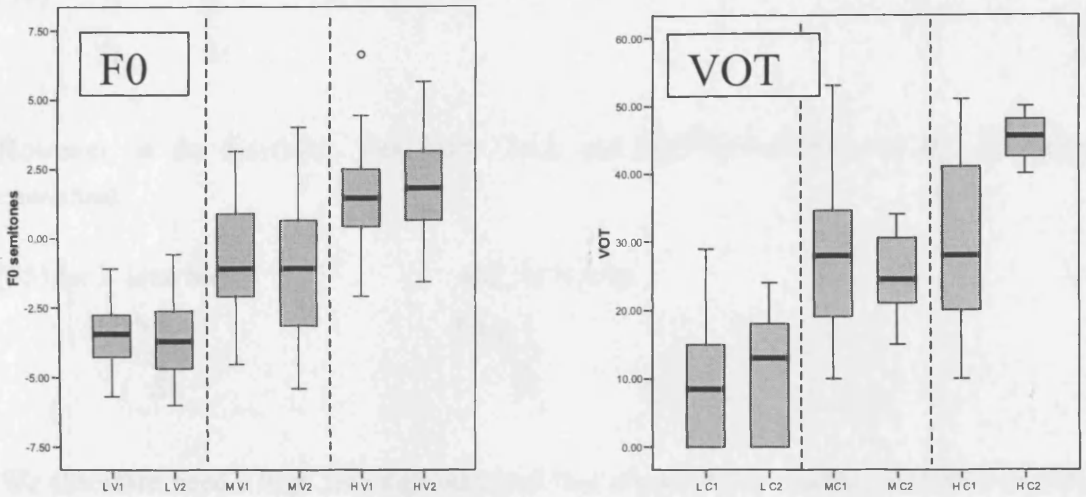
Moving to the Village/Town graphs, we see that the first contrast still has L tone on both vowels, which is what we anticipated, but the VOT is now short on both consonants, giving us b for both consonants.

[17] This bar does not spread as much as we would expect for a P consonant, but it should be noted that the top and bottom values have been marked as outliers (indicated by circles). If they were instead included in the extension of the box plot line, the spread would in fact be what we expect. The consonants which are labeled as b or p do not have outliers.

(52) *Disyllabic feet F0 and VOT – Village/Town speakers*

normalized F0 VOT

ə̀ à ə a ə́ á b b P P P p

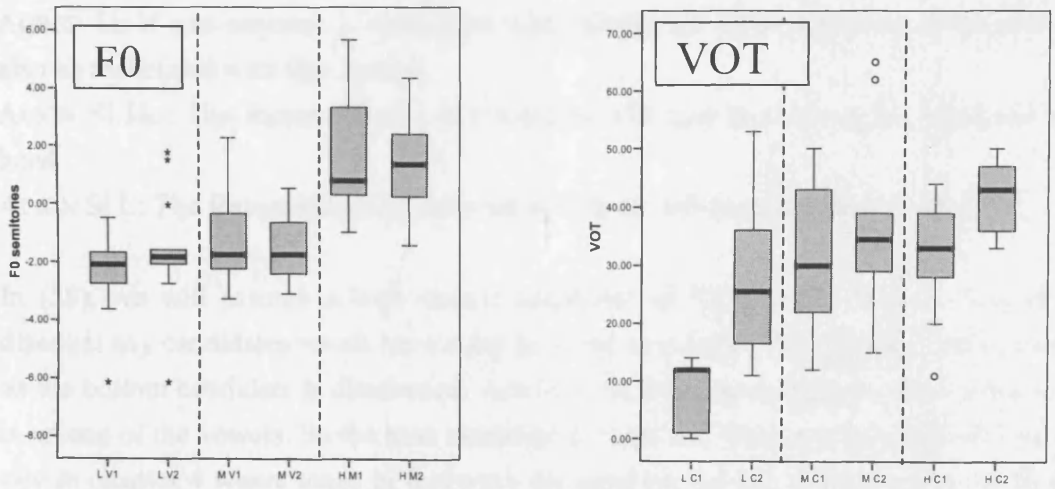


Again the other results are in keeping with our predictions. In the town graphs below, the first contrast has an F0 of M rather than L on both vowels, while the VOT has a short first consonant and a range of VOT for the second consonant, giving us b P.

(53) *Disyllabic feet F0 and VOT – Town Men*

normalized F0 VOT

ə a ə a ə́ á b P P P P p



If we check all our predictions against these graphs, we find that all the predictions hold, so our results confirm the analysis. It seems that the features do spread as we expected them too. This looks very promising, but we do need to revise our constraint ranking to cover a

small problem in the Village Women grammar. At present, we have high ranked constraints as follows:

(54) *C *C
Sl St

However, in the disyllabic foot, both Slack and Stiff spread left onto the intervocalic consonant.

(55) for L tone feet: and for H tone:

P ə̀ b à P ə́ p á
Sl St

We therefore need a high ranking constraint that allows the spreading described in (55) to take place. The constraint NOGAP will cover this situation.

(56) NOGAP: Multiple-linked features cannot skip segments

Other constraints that we will be using are as follows:

(57) AGREE V Sl: If one vowel is associated with [Slack], all other vowels in the foot must also be associated with that feature.
AGREE Sl: If one segment is associated with [Slack], all other segments in the foot must also be associated with that feature.
ALIGN Sl HD: The feature [Slack] is associated with one or more of the segments in the head.
ALIGN Sl L: The feature [Slack] is associated with the left-most segment in the foot.

In (58), we will assume a high ranked constraint of REALISE Sl. We can immediately discount any candidates which have a gap between association lines as they violate NOGAP, so the bottom candidate is discounted. AGREE V Sl forces spreading to occur if the feature is on one of the vowels. So the next candidate is ruled out. This is in keeping with what we saw in chapter 4 where tones in feet were the same on the two vowels wherever possible. The candidate with no [Slack] on either vowel is ruled out by ALIGN Sl HD which eliminates the candidate for not having [Slack] associated with the head. This is a high ranking constraint for Village Women, but not for the other populations. Two candidates remain. The candidate with spreading throughout the word is eliminated because it violates

the constraint avoiding [Slack] on consonants. In fact, both remaining candidates violate this, but the complete spreading candidate violates it twice. This leaves us with the correct winning candidate. The lower ranked constraints are included in the tableau for comparison with the other dialects where they will be needed.

(58) Village Women, disyllabic feet, L tone contrast

Pəpa + [Sl]	NO GAP	AGREE V Sl	ALIGN Sl HD	*C Sl	AGREE Sl	*V Sl
☞ P ə̀ b à (Sl)				*	*	**
b ə̀ b à (Sl)				**!		**
b ə P a (Sl)			*!	*	*	
P ə P à (Sl)		*!			*	*
P ə̀ P à (Sl)	*!				*	*

We have dealt with a number of candidates here, and we appear to have a working solution. But there is one candidate that we have not considered. That is the candidate with [Slack] on the second syllable onset: P ə b a (Sl)

In the above tableau, this candidate would win.

(59)

Pəpa + [Sl]	NO GAP	AGREE V Sl	ALIGN Sl HD	*C Sl	AGREE Sl	*V Sl
P ə̀ b à (Sl)				*	*	*!*
☞ P ə b a (Sl) ☹				*	*	

To eliminate this candidate, we have to change ALIGN Sl HD to ALIGN R Sl where ALIGN R Sl is defined as: 'The feature [Slack] is associated with the right-most segment in the foot.' With this constraint in the position that ALIGN Sl HD was in, the correct candidate wins over Pəba. This may seem like a small change as the head is after all on the right hand side of the foot, but it has theoretical implications concerning the role of the head and the role of the boundaries of the feet. It will also be significant in our later discussion about an alternative analysis (see §6.6.2.1). From this new ranking, we see that the head plays no role in the positioning of the feature, but the boundary of the foot plays an important role.

Now considering the Village/Town dialect, and assuming NOGAP is highly ranked, we get the following tableau:

(60) *Village/Town Men, disyllabic feet, L tone contrast*

Pəba + [Sl]	ALIGN Sl R	ALIGN Sl L	AGREE Sl	*C | Sl	*V | Sl
☞ b ə̀ b à \ Sl				**	**
P ə̀ b à \ sl			*!	*	**
P ə P à | sl		*!	*!		*
b ə P a | sl	*!		*!	*	

This tableau does not motivate the ranking of ALIGN Sl R and ALIGN Sl L, but they are high ranked here because they are high ranked in other dialects and there is no reason to change their ranking. In this tableau, AGREE Sl is enough to eliminate the bottom three candidates as complete spreading is required to satisfy the constraint. REALISE Sl is assumed to be highly ranked so the candidate with no feature is already eliminated.

The Town tableau is given in (61).

(61) *Town Men, disyllabic feet, 'L-tone' contrast*

Pəba + [Sl]	ALIGN Sl L	*V Sl	*C Sl	AGREE Sl	ALIGN Sl R
☞ b ə P a (Sl)			*	*	*
b ə̀ b à (Sl)		**!	**		
P ə̀ b à (Sl)	*!	**!	*	*	
P ə P à (Sl)	*!	*!		*	
P ə b a (Sl)	*!		*	*	

ALIGN Sl L is needed to eliminate the bottom candidate. (Note that this is the candidate that caused a problem for the Village tableau, but ALIGN L Sl deals with it here). The constraint barring [Slack] on vowels eliminates any other candidates.

Assuming that the constraints REALISE Sl, NO GAP, AGREE V Sl are high ranked for all Kera, then the grammars are as follows:

(62)

Village: ALIGN R Sl, *C (Sl) » AGREE [Sl], *V (Sl), ALIGN L Sl

Village/town: ALIGN R Sl, ALIGN L Sl, AGREE [Sl] » *C (Sl), *V (Sl)

Town: ALIGN L Sl, *V (Sl), » AGREE [Sl], *C (Sl), ALIGN R Sl

This gives us an analysis that works but in order to get to this point, we have had to abandon the idea of the head attracting the features and instead use features that align to foot boundaries. This leads us to an alternative analysis which is less conventional, but which might better reflect the importance of the foot boundaries in Kera. In the first contrast for both Village Women and Town Men, we noted that the candidate

P ə b a is not chosen. Instead, we find b ə P a in the Town and P ə̀ b à for Village Women.

Sl Sl Sl

The constraints needed to cover this are ALIGN L Sl and ALIGN R Sl. These must be highly ranked. We do not need any constraints involving heads to be highly ranked. The [Slack] feature is now aligned with the segment at the left or right boundary of the foot. The alternative analysis that we are about to consider takes the emphasis off the segments within the foot and looks instead at the alignment towards the edges of the foot, regardless of what type of segment is nearest to the boundary. It will apply this principle to monosyllabic and disyllabic feet.

6.6.2.1 The foot as 'feature-bearing-unit'

The main point with this analysis is that we are not looking at segments, rather at the edges of the foot. So whether the feature lands on a consonant or a vowel is accidental due to their position in the foot. Whereas in the segment analysis above, the fact that they are consonants or vowels is all important. This is an important theoretical point. We cannot say that both analyses are equally right. Either the features are looking for consonants, vowels and foot structure or they are looking simply for foot boundaries.

In chapter 4 we discussed how the foot is a tone bearing unit in Kera. This alternative analysis is an extension of that analysis. If the tones result from the features [Slack] and [Stiff], then it follows that the foot could be a 'feature-bearing-unit' (FBU). Where a feature is assigned to the foot, this is realised by a target for the feature being placed at the left or right edge of the foot. If the target is at the right edge, for example in the H tone contrast for all dialects (Pə́pá), the preceding consonants and vowels are affected to some extent because the journey towards the target begins at the beginning of the foot. The approach to the target is an asymptotic curve, as described by Xu et al (1999) and Prom-on et al (forthcoming).[18] This 'foot' analysis differs from the previous 'segment' analysis in that while several segments are affected by the target at the right edge of the foot, these segments do not carry the feature in phonological terms. The target for the feature is at the right edge of the foot and all other effects are phonetic. In the previous analysis [Stiff] was associated with 3 segments:

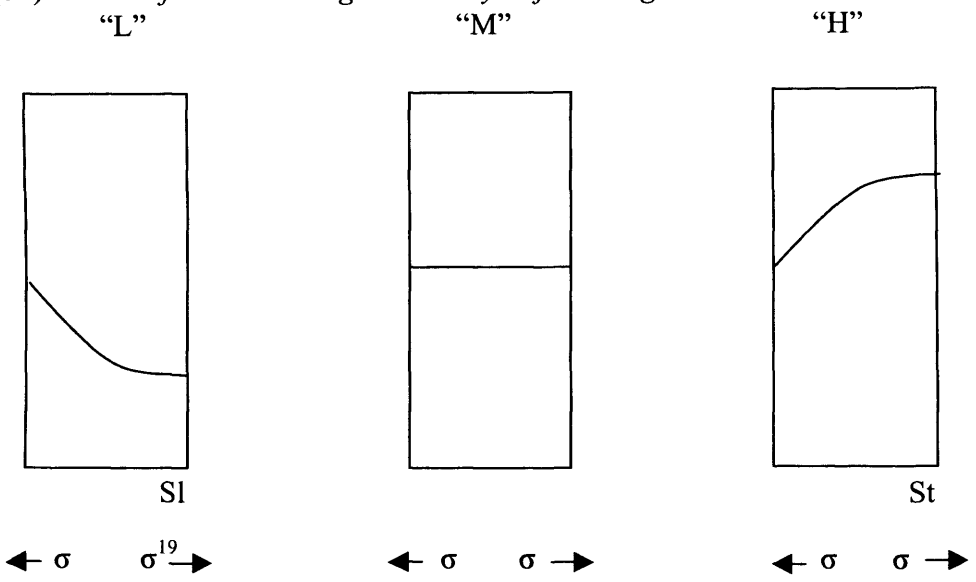
P ə́ p á

St

[18] For Xu and Prom-on et al, the target itself is a line rather than a point, either horizontal or sloping. We will continue to use a point as the target in this paper, but the target line idea would work equally well here.

In this 'foot' analysis, the [Stiff] target is at the right edge of the foot regardless of the segments in the foot. The H tone on [ə] and the quality of the intervocalic consonant [p] are simply phonetic results from muscles moving towards the target. In (63), each schematic rectangle represents a disyllabic foot. In the Village Women dialect, the [Slack] and [Stiff] features have targets at the right edge of the foot for the L tone and H tone contrasts respectively. The height of the line represents the tenseness of the vocal folds.

(63) *'Foot as feature bearing unit' analysis for Village Women dialect*

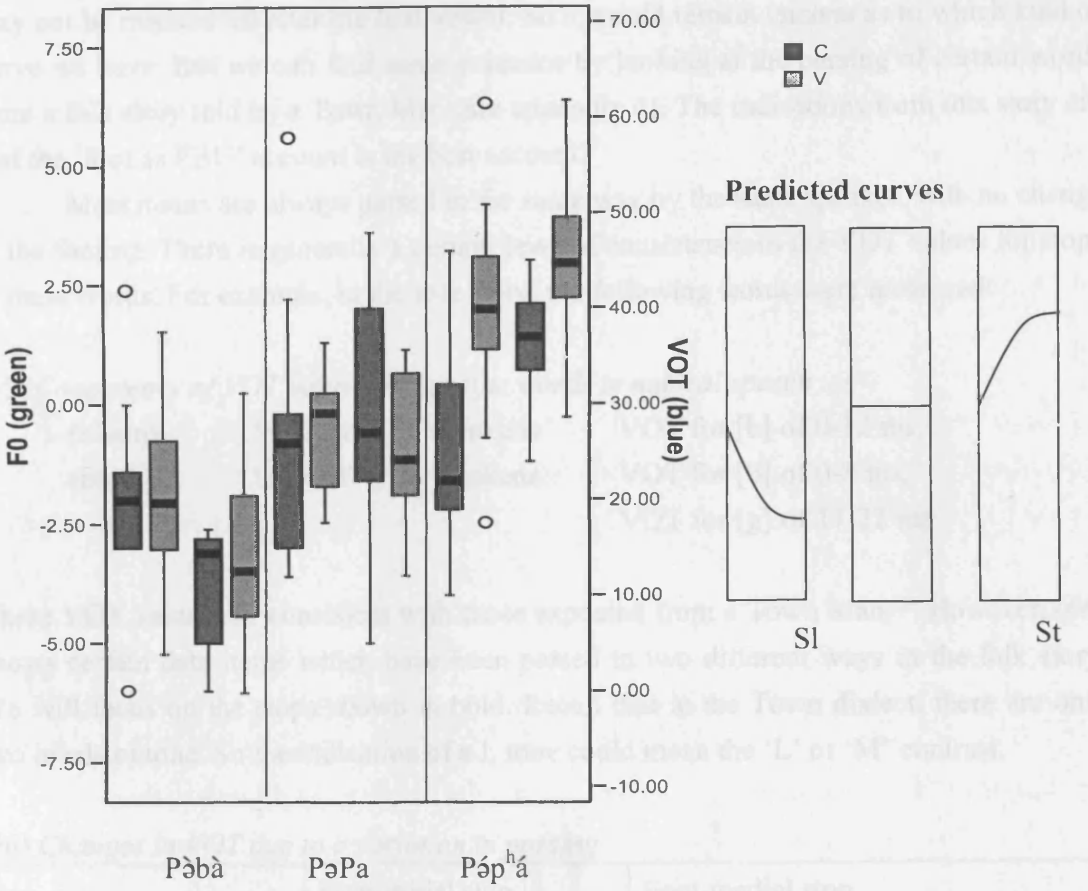


We can evaluate if these schematic diagrams represent reality by combining the F0 and VOT production results in one graph. Of course this does not prove anything as the scales are different for F0 and VOT, but the graphs in (64) for Village Women do suggest that this account is plausible. This account claims that for village women, the features [Slack] and [Stiff] are both aligned with the right edge of the word. We would then expect to see curves like those in (63). In the 'low' tone contrast, the VOT should become progressively shorter and the F0 value lower throughout the word. In the 'high' tone contrast, we would expect the opposite curve. This is what we find.[20]

[19] The syllables are indicated here because they are a part of the disyllabic foot. But the alignment constraints which are central to this analysis ignore the boundaries of the syllables. We will however be introducing another constraint *contour which bans two features within one syllable. For this constraint the edges of the syllable are important.

[20] These results are based on one reading for each segment. It would be possible to take more readings on the vowels to measure the changes over time. An initial test taking more readings of F0 throughout the word arrived at the same curve.

(64) *Combined Village Women results for F0 and VOT*



These graphs suggest that the foot as FBU approach can cover the facts, but we will now consider if this approach gives us anything beyond the more conventional approach of associating features with segments. After all, align constraints can be used with segments as we saw in the previous section. We would like evidence that the foot boundary is the target rather than the edge segments.

There is little experimental evidence to support one view over the other. Both L and H could be analysed both ways and still fit the data. In theory, we could measure for a difference in the various foot structures such as (VCV:) and (CVCVC), because the two models would predict differences. However, because vowel initial feet are very rare and because tones generally spread onto the final consonant if a sonorant, there is nothing conclusive for us in this research. If the segmental approach is correct, we would expect the tone to reach the target in the first vowel, whereas if the 'foot as FBU' approach is correct, we might expect the asymptotic curve to go slower so that the target is only reached in the second vowel. The problem with trying to tease these apart is that it would require a large amount of data to detect the subtle differences. Xu and Sun (2000) have claimed that a

certain time is required to arrive at a target. This suggests that in both approaches, the target may not be reached till after the first vowel. So it would remain unclear as to which kind of curve we have. But we can find some evidence by looking at the parsing of certain words from a folk story told by a Town Man (see appendix 4). The indications from this story are that the 'foot as FBU' account is the best account.

Most nouns are always parsed in the same way by the same speaker, with no change in the footing. There is generally a certain level of consistency in the VOT values for stops in these words. For example, in the folk story, the following words were measured:

(65) *Consistency of VOT values for specific words in natural speech*

(bàa)ŋà	'elephant'	8 tokens	VOT for [b] of 0-12 ms.
(bègé:)	'animal'	5 tokens	VOT for [b] of 0-8 ms,
			VOT for [g] of 17-22 ms.

These VOT values are consistent with those expected from a Town Man. [21] However, (66) shows certain data items which have been parsed in two different ways in the folk story. We will focus on the stops shown in bold. Recall that in the Town dialect, there are only two levels of tone. So the indication of a L tone could mean the 'L' or 'M' contrast.

(66) *Changes in VOT due to a variation in parsing*

	Foot-initial stop	Foot-medial stop
a. gɔ̀rnɔ̀y 'hyena' (5 tokens) VOT:	(i) (**gɔ̀**r)(nɔ̀y) g: 5-11 ms	(ii) (**dɨkɔ̀**r)(nɔ̀y) 'of hyena' d: 0-9 ms k: 22 ms
b. ákɔ́bàrnɔ̀wà 'ants' (3 tokens) VOT:	(i) (**áká**:)(**bà**r)(nɔ̀wà:) k: 23 ms b: 0 ms	(ii) ...á:)(**kɔ́pá**r)(nɔ̀wà:) k: 25-31 ms p: 10-22 ms
c. gìwgìwì 'bat' (3 tokens) VOT:	(i) (**gì**w)(**gì**wì:) 1st g: 0-11 ms 2nd g: 5-13 ms	(ii) *(kúu)(rɨ́***k**ìw)(**gì**wì:) 'neck of bat' bold k: 37 ms g: 15 ms
d. ábìidɪ̄wbìidɪ̄w 'dragonfly' (2 tokens) VOT:	(i) (**bì**i)(dɪ̄w)(bìi)(dɪ̄w) b: 0 ms	(ii) (**áp**ìi)(dɪ̄w)(bìi)(dɪ̄w) p: 19 ms

[21] Note that <g> in (bègé:) could easily be written as <k>, but <g> has been retained here because of the orthography and because of references to this word elsewhere in this thesis.

In (66a.), the stop at the left edge of the foot has a VOT that is consistent with a [Slack] feature being associated with this position. But when a clitic is added so that the <g> is no longer foot-initial, the VOT value changes. This implies that the [Slack] is aligned with the left edge of the foot rather than the initial stop of the word or the head of the foot.

(67) dɨ gɔ̀rnɔ̀y > (dɨ̀kɔ̀r)(nɔ̀y)

Sl Sl Sl Sl

(The dotted line indicates that we cannot be sure if this association line is there or not because the F0 for 'L' equals the F0 for 'M'.)

The fact that a syllable is word-initial and in head position is clearly not enough to guarantee that [Slack] will be associated with that syllable in the output. There is one feature per word and it appears to align to the edge. A similar example is seen in ákɨ́bàrnəwà 'ants' (66b) where the initial a- is parsed with the preceding word in some cases, but the following syllable in others. The presence of [Slack] is evident in (i) on [b], but in (ii) the [Slack] only appears in the following foot. This example suggests that the [Slack] is not associated with the /b/ when it is no longer at the edge of the foot. It moves to the right to the next foot.

In (66c ii), the final syllable of the preceding word has been footed with the word under consideration. In (66d), the a- prefix is optionally included in the foot. In both of these cases we would perhaps expect the stops marked in bold to have the feature [Slack] because they are onsets for the head syllable in each case, but the VOT values show us that in disyllabic feet, the feature is not realised (maybe because there is not time for the transition from [Stiff] to [Slack]). When the feature [Slack] targets a syllable, we expect stops to have a short VOT. So this evidence suggests that the features are not associated to the head, but rather to the foot boundary.

The evidence in (66c and d) is less strong because we might be dealing with undershoot with the features remaining on the segments in question, but (66a and b) suggest strongly that the onset of the head of the foot does not have the status that we would expect. For an account that involves features associating with segments, this is a problem. It is generally considered to be a universal that tones associate with heads, for example in Shanghai (chapter 4, §4.6, Duanmu 1994), so it is incongruous if these features appear to move away from heads onto non-head segments. However, this is not a problem for the 'foot as FBU' approach because that approach focuses on the edges of the foot, with alignment to the left, right or both.

We have considered some of the arguments for the foot being the FBU. The full argument is as follows:

(68) *Main arguments for foot as FBU approach, based on boundaries of foot*
(i) I have already established in chapter 4 that the tone bearing unit is the foot. The claim that the foot is in fact a feature bearing unit for laryngeal features fits in with this well.
(ii) The asymptotic curves and targets that I proposed in (63) and (64) fit well with the data. If the association is to segments, there is no explanation as to why some segments appear to carry a greater amount of the feature than others.
(iii) The head does not appear to be the target. Instead the edges of the feet are the targets. This means that alignment to the edge is in focus rather than specific segments.
(iv) Accidental traces of the effects of the features appear on the intervocalic consonant, but this consonant does not behave as if it is associated with the feature. I conclude that the onset of the second syllable of a disyllabic foot is not targeted with a feature.
(v) In this model, there is a symmetry between the analysis for the syllable and the foot, which leads us to propose that heavy syllables act as they do because they are monosyllabic feet. (This is discussed further below).
(vi) The grammars that result from using the segment approach imply that the historic change involved discrete changes, whereas the 'foot as FBU' model lends itself more to gradual phonetic change.
(vii) In both models, I use ALIGN constraints. These constraints are particularly well suited to the concept of foot edges and phonetic targets as found in the 'foot as FBU' model and less well suited to anchoring on segments as found in the segment model.
So what we have found is that for Kera, the features align themselves to the left or the right of the foot and we can describe everything in terms of [Stiff] and [Slack]. The H tone in Kera is made with [Stiff] aligned right. The L tone is made with [Slack] aligned right. When aligned left, it produces a foot-initial consonant with short VOT. The Village/Town Men combine these two uses of [Slack] so that the alignment is both left and right. This means that from the left edge of the foot, the target is [Slack], but the muscles are not released until the end of the foot. So between the three dialects, we have the three possibilities for the feature [Slack]:

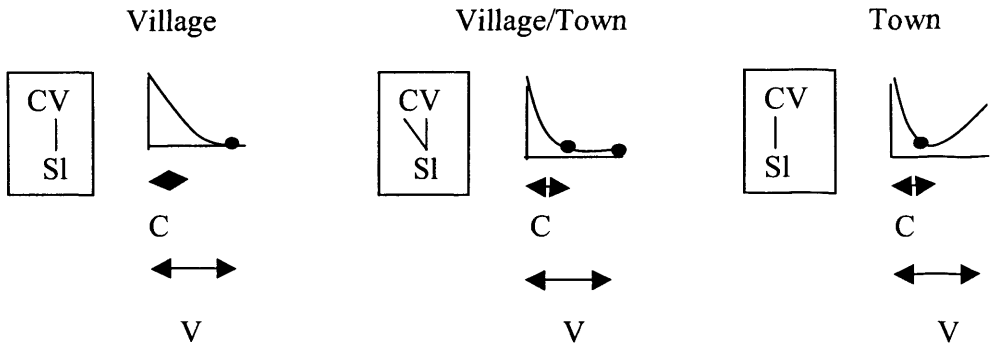
Village women: ALIGN R
Village/Town men: ALIGN L, ALIGN R
Town Men: ALIGN L

6.6.2.2 Foot as FBU in Optimality Theory

I will begin with the syllable. There are three possibilities: A feature can be aligned to the left (apparently on the C), aligned to the right (apparently on the V) or aligned to both boundaries (apparently on C and V). These possibilities are shown in (69). A dot

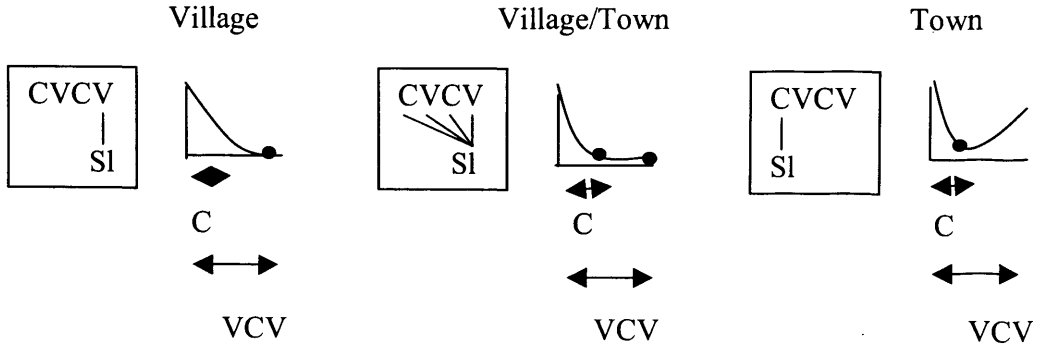
indicates the target in the phonetic realisation of the syllable. I show the models for [Slack], but similar diagrams could apply to [Stiff]. I am assuming the model of Xu (forthcoming) where the onset C and V start at the same time, but I could equally use the model of Browman and Goldstein (1988), Hall (2003) and Gafos (2002) where the V starts at the centre point of the C. All of these models assume some overlap which makes the concept of spreading from C to V and vice versa more plausible. They also bring into question the standard segmental representation of V following C. In these diagrams, the CV representations (in boxes) have no reality. They are included for comparative purposes only. The vertical axis represents vocal fold tension.

(69) *Syllable target diagrams*



The same logic is applied at foot level in (70), so the target is at the beginning or end of the foot, or both. Note that the left aligned target is drawn towards the end of the consonant. It may be that the target is near the beginning, but that phonetically, it is impossible to reach a target instantaneously. This means that in practice, the realisation of the target may well be towards the end of the consonant.

(70) *Foot target diagrams*



This analysis claims that the FBU is the foot, and that the target can be positioned at the left or right edge of the foot, or both. These target positions are covered by the ranking of ALIGN left and ALIGN right. The use of ALIGN with gestural targets is based on the work of

Gafos (2002) and Hall (2003) who apply this approach to the gestures in each segment. Here I develop the same idea applied to the foot.

In the final diagram of (69) and (70), there appear to be two targets, but this situation represents one target with a delayed release of the muscles producing [Slack]. These muscles keep the vocal folds slack from the first target point to the second. It should be remembered that [Slack] does not mean that the muscles are slack. To produce [Slack] vocal folds, the vocalis muscle is actually tense. The norm is to release this tenseness once the target is reached, but in the Village/Town grammar, there is a greater duration between the target and release as the target aligns with the left edge of the foot while the release aligns with the right edge. In the constraints below, I will use *MAINTAIN to signify that the target and release must be at the same point (as near as is physically possible). The grammars that I will be claiming are essentially:

(71) *[Slack] constraint ranking for 3 populations*

Village: ALIGN R Sl, *MAINTAIN » ALIGN L Sl

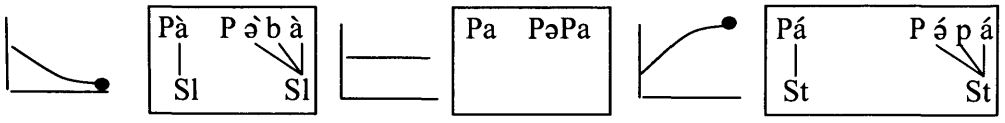
Village/Town: ALIGN R Sl, ALIGN L Sl » *MAINTAIN

Town: ALIGN L Sl, *MAINTAIN »ALIGN R Sl

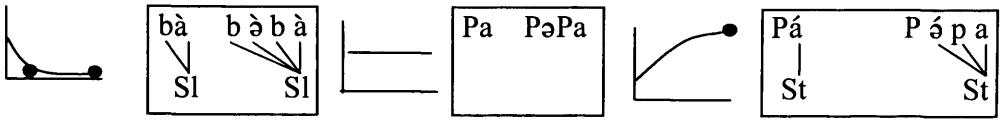
If I represent [Stiff] as upward and [Slack] as a downward target (assuming the y-axis to be a measure of vocal fold tension), then [Stiff] appears as  and [Slack] as  (This is applicable to mono- and di-syllabic feet). The schematic diagrams using targets will then be as follows. The information in boxes is provided for comparison with the previous model.

(72) *Target diagrams for contrasts in each population group*

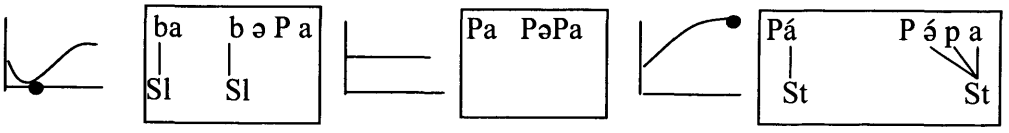
Village



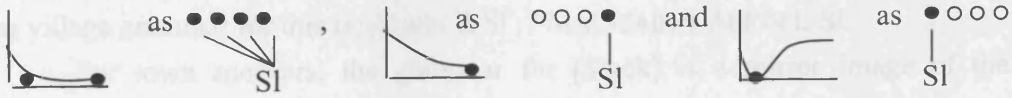
Village/Town



Town



In the Optimality Theory tableaux below, for convenience I will indicate



Note that the middle case represents Pə̀bà with both vowels deviating from the default M tone, yet only one dot is shaded because the claim of the theory is that [Slack] is aligned to the right, and that earlier effects on the muscles as they move towards the target, are simply phonetic.

In all tableaux, I will assume that one input means one output. In the first few tableau, as there is only one input feature, I will further simplify the diagram by drawing simply: ●●●● This implies that the target is reached at the first black dot and is held to the last black dot. The number of black dots in between denote only the span of the hold, and not that there are additional anchor points. These dots do not represent segments. The first two represent the left and right edge of the first syllable and the last two, the second syllable. In all of the following tableaux, the candidates are all exactly one foot, so the foot structure is not shown. When there is one feature in the input, the candidates that we need to consider are as follows:

(73) *Candidates to consider*

●○○○	●●○○	●●●○	●●●●
○●○○	○●●○	○●●●	
○○●○	○○●●		
○○○●			

I will assume that the following constraints are undominated: REALISE F, *CONTOUR (syllable). For speakers of all dialects, the 'H tone' has [Stiff] aligned right, so I will begin with this grammar: ALIGN R St , *MAINTAIN » ALIGN L St. It is clear in the tableau below that any candidate with more than one black dot will be eliminated by *MAINTAIN and that the optimal candidate has Stiff aligned right.

(74) *H tone contrast for all speakers*

+ St ○○○○	ALIGN R St	*MAINTAIN	ALIGN L St
☞ ○○○●			***
○○●○	*!		**
○●○○	**!		*
●○○○	***!		
○○●●		*!	**

A similar tableau could be used for the village 'low tone' with [Slack] replacing [Stiff]. So the village grammar for this is: ALIGN R Sl , *MAINTAIN » ALIGN L Sl.

For town speakers, the grammar for [Slack] is a mirror image of the village grammar: ALIGN L Sl , *MAINTAIN » ALIGN R Sl

(75) *Town Men 'L tone constrast'*

○○○○ + Sl	ALIGN L Sl	*MAINTAIN	ALIGN R Sl
☞ ●○○○			***
○●○○	*!		**
○○●○	**!		*
○○○●	***!		
●●○○		*!	**

For Village/Town speakers, the grammar has both aligns ranked above *MAINTAIN, with the result that the feature [Slack] is held for the duration of the foot. The grammar is:
ALIGN L Sl , ALIGN R Sl » *MAINTAIN

(76) *Village/Town Men 'L tone contrast'*

○○○○ + Sl	ALIGN R Sl	ALIGN L Sl	*MAINTAIN
☞ ●●●●			*
○○○●		***!	
●○○○	***!		

This completes all the cases that we have considered so far in this chapter, but we still have the case where a disyllabic foot carries two tones. This will be modeled in the next section.

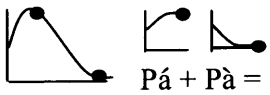
6.6.2.3 Disyllabic feet with two tones

In chapter 4, I referred to disyllabic words made up of one foot and having two tones. eg *bègɛ́:* 'cattle'. I claim in Pearce (2006a) and in chapter 4 that this is motivated by the need for both tones to be realized. If the word has two syllables and also two tones, one tone is associated with each syllable even if there is only one foot. It is debatable whether the syllable has become the TBU. It could be that in this case only, the foot allows a contour, and that this is realized by having one tone on each syllable because there is another high ranked constraint that does not allow contours on syllables. Applying this to the [Stiff] and [Slack] features, we can say that [Stiff] and [Slack] are not allowed on the same syllable,

and are only allowed on the same foot if they need to be to be realized. In (77), I take the analysis already worked through for syllables in (72) and combine two syllables together with opposing features.

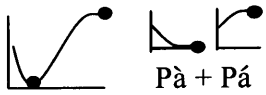
(77) Village

St + Sl



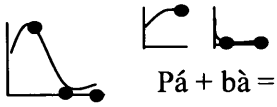
Pá + Pà = PəPà

Sl + St

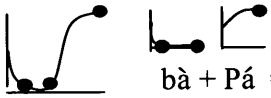


Pà + Pá = PəPá

Village/Town

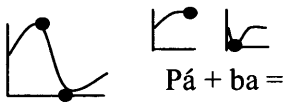


Pá + bà = Pəbà

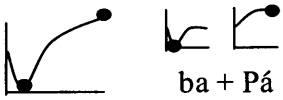


bà + Pá = bəPá

Town



Pá + ba = Pəba



ba + Pá = bəPá

Note that there is support here for the analysis that M is default: These disyllabic feet always involve [Stiff] and [Slack]. No "HM" foot involving the top two contrasts exists in Kera. If it did, this model would have a problem. If the middle contrast means a lack of [Stiff] or [Slack], then the foot would only have one feature, and it would behave as already described for the feet with one feature. It would not produce a drop in F0 to a 'middle ground'.

If the predictions are correct, our grammars in §6.6.2.2 will still work for these feet. We still assume REALISE F (so all features must be realized), and *CONTOUR (so [Stiff] and [Slack] cannot appear in the same syllable). To this we add LINEARITY, which means that features are ordered in the lexicon and they must have the same order in the output.

In (74), the Village grammar is established as: ALIGN R St, *MAINTAIN » ALIGN L St. We also assume that *CONTOUR rules out two features on the same syllable. So for the input with [Stiff, Slack] in that order, the candidates that we consider first are those with various possibilities for the aligning of [Stiff] on the first syllable. Note that the association lines in the diagrams below are actually indicating alignment to the edges of feet or syllables. (Recall that the first two dots represent the first syllable and the last two dots, the second syllable).

(78) Village PɔPà

○○○○ + St, Sl	*CONTOUR	*MAINTAIN	ALIGN R St	ALIGN L St
○●○● ☞ St Sl			**	*
●○○● St Sl			***!	
●●○● St Sl		*!	**	
○○●● St Sl	*!		*	**

The last candidate violates the *CONTOUR constraint as the two features are on the same syllable. The constraint *MAINTAIN rules out any possibility of [Stiff] holding for any duration, and the ALIGN R constraint ensures that [Stiff] aligns as far to the right as is possible without violating *CONTOUR. We are left with [Stiff] aligning to the right of the syllable. We now consider the feature [Slack]. The grammar that I had established before in (71) had the ranking: ALIGN R Sl, *MAINTAIN » ALIGN L Sl. Combining this grammar with the tableau above, and including candidates that differ in the placing of [Slack], we get the following tableau.

(79)

○○○○+ St, Sl	*MAINTAIN	ALIGN R Sl	ALIGN R St	ALIGN L Sl	ALIGN L St
○●○● ☞ St Sl			**	***	*
○●●○ St Sl		*!	***!	**	*
○●●● St Sl	*!		**	**	*

*MAINTAIN again rules out any candidate with a feature holding for any duration, and ALIGN R Sl ensures that [Slack] aligns to the right of the foot. So we see that the grammar we had already established still holds in these more complicated cases. The tableau for Village PɔPá is similar, but with the features reversed.

The Town constraints also follow the same kind of pattern. I will not include all of these examples here, but the arguments are essentially the same. The most interesting case that remains is the Village/Town case. For these speakers, a different argument is required

as *MAINTAIN is low ranked, and this gives us various possibilities of features being held for a longer duration. As with the examples above, *CONTOUR still bans any candidates with a mixture of features in one syllable. So the candidates I need to consider are those with [Stiff] aligned to one or both edges of the first syllable and [Slack] aligned to one or both edges of the second syllable. I will consider [Slack] first, using the grammar already established for the Village/Town speakers in (76).

(80) Village/Town Pə́bà

○○○○ + St, Sl	ALIGN L Sl	ALIGN R Sl	*MAINTAIN
○●●● ☞ St Sl	**		*
○●○● St Sl	***!		
●○●○ St Sl	**	*!	

The winning candidate now has [Slack] aligned to both edges of the final syllable.

Now adding the constraints for [Stiff] in the ranking already established, and considering the candidates demonstrating the various possibilities for the feature [Stiff], we get the following tableau.

(81)

○○○○ + St, Sl	ALIGN L Sl	ALIGN R Sl	ALIGN R St	*MAINTAIN	ALIGN L St
○●●● ☞ St Sl	**		**	*	*
●●●● St Sl	**		**	**!	
●○●● St Sl	**		***!	*	

ALIGN R St rules out the bottom candidate, so we are left with the possibility of [Stiff] aligning to both edges of the syllable, or just the right edge. Although for the feature [Slack], *MAINTAIN has to be relatively low ranked, we now see how it needs to be higher ranked than ALIGN L St so that the feature [Stiff] is not held for any duration. Again, the previously established grammar has given us the correct result.

The only case that remains is the Village/Town L tone contrast. We will consider the [Slack] feature first and then add the [Stiff] feature.

(82) Village/Town bə̀Pa

○○○○ + Sl, St	ALIGN L Sl	ALIGN R Sl	*MAINTAIN
●●○● ☞ Sl St		**	*
○●○● Sl St	*!	**	
●○○● Sl St		***!	

Again, the established grammar gives us the candidate we require. Now adding the [Stiff] constraints:

(83)

○○○○ + Sl, St	ALIGN L Sl	ALIGN R Sl	ALIGN R St	*MAINTAIN	ALIGN L St
●●○● ☞ Sl St		**		*	***
●●●● Sl St		**		**!	**
●●●○ Sl St		**	*!		**

Once more the grammar we established in (71) and (75) still gives us the correct candidate. I have now covered all of the cases where feet contain two tones. These tableaux show that the original grammars from (74)-(76) still apply.

6.6.2.3. Summary

For all Kera speakers, the undominated constraints are: REALISE F, *CONTOUR and LINEARITY. Also for all speakers, ALIGN R St » ALIGN L St. This ranking effectively locates [Stiff] on the vowels (or on the coda in heavy syllables), with the result that in all the dialects considered here, the H tone remains as a tone and is perceived as such.

The remaining constraints are ranked as follows:

(84) *Constraint ranking for dialects*

Village:

***MAINTAIN, ALIGN R Sl,** ALIGN R St » **ALIGN L Sl,** ALIGN L St

Village/Town:

ALIGN L Sl, ALIGN R Sl, ALIGN R St » ***MAINTAIN** » ALIGN L St

Town:

***MAINTAIN, ALIGN L Sl,** ALIGN R St » **ALIGN R Sl,** ALIGN L St

So we have been able to construct grammars only in terms of the foot boundary. However, there are a few issues that we still need to address if we take the foot as the FBU.

If the foot has the structure CVCVC, then this implies that the ALIGN R constraint anchors on the final consonant. A word like *bègɛ́ŋ* would only get the true H tone on the final consonant. It would be difficult to measure this exactly, but from the data available, this analysis is possible. In words like this, the H tone on the vowel often looks more like M which could imply that the target is on the coda C. So this first challenge is not necessarily a problem.

More of a challenge is the foot with the structure VCV. The segmental approach predicts that if the town "L" is b ə P a, then VCV becomes aPa (no associated features).

Sl

But the foot level approach predicts that in the absence of an onset C, the align L gives à P a.

Sl

The presence of L tone could be measured, but there aren't many examples of words of this form, and in natural speech, because of elision and avoidance of hiatus, most feet have an onset even if this is "borrowed" from a preceding word. Failing that there is a preceding glottal stop which could be the anchor for the feature. For these reasons, measurements probably wouldn't clarify the situation.

Another contrast between the two approaches is that the standard approach implies discrete changes between grammars whereas the 'foot as FBU' model captures the phonetic changes. In the foot model there can be phonetic changes in the speed with which the muscles move towards or away from the target. If the movement away is slower, it can lead to the eventual perception of two targets (the first for the position and the second for maintaining the position). Further phonetic changes can take place from two targets down to one as the position is not held for quite so long, and eventually only one target is perceived. The transaction between phonetics and phonology is smoother in this approach than in the segmental model.

The fundamental issue in the choice between the segmental or FBU approach is whether the difference on foot-medial segments is intentional or accidental. The segmental approach says it is intentional and phonological, while the 'foot as FBU' approach says it is accidental and phonetic. In both approaches, there has to be a reference to alignment to foot edges. But the segmental approach also refers to non-edge segments.

My conclusion from this discussion is that although both approaches are possible, the 'foot as FBU' approach seems simpler and more able to grasp the link between phonetics and phonology in a way that the segmental approach does not. Therefore I suggest that further research into this approach would be valuable, to see if other languages could be analysed in a similar way and to see if this furthers our understanding of the interaction between the foot structure and the domains of spreading of laryngeal features.

6.7. Conclusion

We began this chapter by investigating and concluding that the feature [voice] is not present in Kera and that claims of voicing spread are not supported by the data. This means that the other languages that are included in the claims of voice spreading should be re-examined. It also means that Chadic languages should be measured for voicing. For most of them, voicing is assumed without measurement.

We then went on to consider various laryngeal models with the goal of finding which of them best models the Kera facts. We found that the first of them, Halle and Stevens (1971), is still the best for this task. This is not to reject other models for other languages, but to acknowledge that the simpler and earlier model still covers all that is necessary, providing an analysis that fits remarkably well with detailed acoustic measurements.

The Halle and Stevens model was applied to all diachronic stages and all synchronic variations of Kera. For each one, we developed a grammar and investigated how this would be developed to cover the foot structure patterns. The [Slack] and [Stiff] features and a small set of ALIGN constraints are all that is required to account for all of the main tone and VOT facts in Kera. The beauty of this analysis is that it requires only one dimension of laryngeal movement to cover it all.

Finally we considered two possible approaches to the analysis of how tones and VOT behave in feet: the more conventional segmental approach and the 'foot as FBU' approach. The foot approach was found to be the simpler of the two. Experimental data also suggests that when the onsets of heads appear to carry a feature, this is accidental rather than deliberate as a result of phonetic movement towards a target. This gives tentative support for the foot approach. However, both approaches are possible and if the segmental approach is preferred, the reader should not reject the interesting data of the role of the foot

in setting the domains of the laryngeal features simply because of the analysis presented at the end of the chapter.

Over all, this chapter shows the importance of accurate and detailed measurements and of balancing the description of real data with thorough linguistic theory. Without the measurements, we would assume that Kera has the feature [voice] because linguists, especially if English speaking, tend to hear voicing even for positive VOT values. Without the data, the theory would not be grounded, and we would have very little proof as to which model works best. But without the theory, we would not see the beauty of the system where two features, a few constraints and a foot structure provide the basis for an intricate system and a fascinating variety of grammars.

Chapter 7
Conclusion

In chapter one, the aims of this thesis were given as (i) providing a description of certain aspects of the phonology of Kera, using new first-hand data, detailed acoustic measurements, and careful statistical analysis, (ii) addressing current theoretical issues and questions of typology and sociolinguistics on the topics covered in the thesis within a framework of Optimality Theory. There has therefore been a deliberate attempt to cover aspects of the phonology which will be of interest to both descriptive and theoretical linguists.

We began by establishing that Kera has iambic feet. The main evidence for this comes from the deletion and lengthening of vowels to avoid the badly-formed (CVCV) foot. We considered further evidence from duration, intensity and quality measurements, and the behaviour of non-footed syllables. We also acknowledged the role of the foot structure in both vowel harmony and tone spreading.

A further investigation of the vowel harmony system in chapter 3 led to the discovery that the harmony operates over three different domains: the Morphological Word, the Prosodic Word and the foot. Kera has total harmony, height harmony, fronting and rounding harmony with Parasitic Harmony where the trigger and target must both be [+high] and a further kind of fronting harmony with the foot as the domain. The use of the foot as a harmony domain is typologically unusual. Also of interest is the fact that [+high] spreads in a feature dominant system and the fact that suffixes act as triggers for all types of harmony. The main focus of the chapter was on the interaction of vowel harmony with the metrical structure. We concluded that in Kera, the building blocks of the foot and the Prosodic Word have important functions, arguably as important as the syllable.

The rest of the thesis concentrates mainly on tone. In chapter 4, we considered the relationship between the metrical structure and the tonal system. The standard Kera dialect has three contrasting tones. In mono- and di-syllabic words, a different tone may appear on each syllable, but in words with three or more syllables, the foot is the tone bearing unit. Even without overt stress at the word level, Kera shows that it is possible to have an interaction between the foot and tone. Kera reveals how a tonal system can be sensitive to metrical structure, but this relationship only surfaces when the condition of realizing all of the tones is also satisfied. So if a word has more tones than feet, a tone will appear on each syllable as necessary even if this means a foot has more than one tone.

In chapter 5, we concentrated on acoustic measurements and experimental evidence showing the interaction between phonological and phonetic structures. We considered how

the tones may have developed in Chadic languages including Kera and then looked at the differences in the use of tone and voicing in synchronic dialects. By considering populations from village and town locations, we could see that Kera is a language in the process of change. In the village location, the F0 value is the major cue for tonal contrast and the VOT value has a subsidiary and non-contrastive role in enhancing the tonal contrast. Perception and production tests have both shown this to be the case. But the data from Kera town speakers shows that contact with French is having an influence on their Kera. Its effect is that the use of VOT increases and the use of F0 is reduced. By looking at data from excited speech, we concluded that the relationship is between VOT and tone rather than between VOT and the phonetic F0 value. We found an interesting sociolinguistic aspect to the differences in dialect between the populations tested, concerning the differences due to gender. The village women gave the most conservative results with the VOT role reduced to almost nothing, whereas the town women were the most progressive to the point that their results pointed to a grammar with very little space for tonal information.

To summarise, the changes in the Kera tone and VOT relationship are as follows:

(1) *Changes in diachronic and synchronic Kera*

a. 2-way voicing contrast, no tonal contrast (Proto-Chadic)

b. 3-way tonal contrast, voicing lost (Village Women, through tonogenesis)

c. 3-way tonal contrast, VOT enhancing L tone (Village/Town Men)

d. 2-way tonal contrast, 2-way VOT contrast (Town Men in contact with French)

e. Move towards 2-way VOT contrast, no tonal contrast (Town Women)

Note that the net result of these changes is that some Kera speakers appear to be returning to the 2-way VOT contrast that Kera started with having abandoned the 3-tone system.

In chapter 6, we considered the issues raised by these results concerning voice and tone spreading and the choice of models concerning laryngeal features. We saw that the feature [voice] is not present in Kera and that claims in the literature that Kera demonstrates long-distance voice spreading are not supported by the data. Up to now, there has been an assumption in work on most Chadic languages that a feature [voice] exists, but the arguments presented here for Kera raise questions about whether those assumptions are justified. Instead of using the [voice] and tone features that have been adopted up to now, we considered various laryngeal models and found that the laryngeal model of Halle and Stevens (1971) (involving the features [Stiff] and [Slack]) fits the Kera facts well with just a little adaptation. We applied this model to all of the Kera stages outlined in (1). We also discussed how this could be developed to cover the foot structure patterns. In the approach

developed here, we treated the foot as the feature bearing unit with the target for the feature operating over the whole foot rather than associated with a syllable or segment.

Over all, this thesis tries to demonstrate the importance of accurate and detailed measurements using first-hand data. There are many dangers associated with an approach that relies on the transcriptions of others. On the other hand, I have also tried, with the help of linguistic theory, to develop arguments from the data that go beyond the descriptive account and which question why certain patterns emerge. The acoustic measurements and tests have helped us to see the fact that Kera does not have the feature [voice] and that it does have an interesting variation across populations in terms of the VOT/tone relationship. The vowel harmony system has also been clarified with the help of a number of recordings, and certain tests have also hinted that the metrical structure is in some way a reality in the minds of the Kera speakers. The theoretical analysis with the help of OT as a framework has helped us to see the beauty of the various systems described, and how they link together. It helps us to argue against the voice spreading arguments with an alternative account involving tone, and it helps us to see how the foot structure interacts with the tone and vowel harmony systems in a way that makes sense once we postulate the ranking of a few key constraints.

Another area highlighted by this thesis is the interaction between phonetics, phonology, sociolinguistics and psycholinguistics, seen particularly in the facts concerning changes in the use of tones and voicing as a result of French contact. The Kera data raise questions such as whether adults have plasticity in their grammar, and the reasons for the differences in grammars between the genders and between town and village women. I have tentatively suggested that the women may be driven by awareness of prestige, but much more research could be done in these areas. It would be helpful to do a longitudinal study and also to try to devise experiments which will highlight whether the motivation is prestige or some other area. It would be important to study the town situation particularly and to note the influences on the men and women in terms of contact with French. Recordings of town children would also be useful. In all of this, I would like to find out more about the sociolinguistic issues that are important here.

An interesting area for further study would be to widen the scope of the instrumental measurements that have been taken. For example if the laryngeoscope or other more intrusive instruments could be used, then certain assumptions about articulatory movements made here could be verified. However, it seems unlikely that such experiments would be practical at the present time.

The phonetics/phonology interface is a current topic of debate. Theories differ in how much they attribute to phonetics and how much to phonology, and this thesis cannot attempt to answer all the questions that are raised, but it does suggest several areas for

future research: I would like to see more investigation into the tonal/laryngeal systems in other Chadic languages, looking both at clues concerning the developments of tone, but also investigating the synchronic changes that may be taking place. The languages that surround Kera geographically would make a good starting point. References have been made to Masa and Musey with the research of Theda Schumann and Aaron Shryock respectively, but it would be good to link their research with mine, and to look at other languages where very little has been done. Also Kwang is not particularly close geographically, but it is considered to be the linguistic neighbour of Kera. I would like to investigate if that nearness extends to the phonology or just on the level of a comparative list. This might give clues as to which phonological changes are most recent particularly with regard to VOT and F0 values and the use of tones and voicing. A similar investigation into the metrical structure of other Chadic languages would be interesting, and the role of the iambic foot in affecting syllable structure.

More research could be done in the area of plasticity in adults exposed to a new dialect and in the changes in the perception and production of Town Women if they return to their family in a village location. Also more could be done in observing and measuring the changes in the VOT and F0 use among each population over the next few years, and in further measuring the effects of language contact on L1 and L2. It would certainly be helpful to increase the number of town Kera measured. At the other end of the scale, it would also be helpful to measure more village men, particularly those with very little contact with French. Spectral tilt and voice offset time could also be investigated, enabling us to compare Kera with Musey (Shryock 1995). I have more recordings available for this purpose awaiting analysis.

Another area to investigate further would be the question of whether the allophones really are phonological entities or whether the whole system is best described in terms of undershoot with a more phonetics based account. The research by Gendrot and Adda-Decker is interesting in this respect and it would be helpful to develop their ideas further with studies on Chadic and Chadian languages, particularly those with vowel harmony as this may affect the reduction of vowels.

Finally, more could be done to investigate some of the theoretical ideas that I have started to develop such as the concept of the foot as a feature bearing unit and how that can be modelled. To test these ideas, I would need to find more languages which behave somewhat like Kera. There may be some among the Chadic languages that have not yet been investigated to any depth.

This thesis raises as many questions as it answers, but the overall aim has been to highlight the richness of the Kera phonology and show that a careful study with first-hand recorded and measured data, combined with a theoretical analysis, can provide many

interesting and thought provoking new areas of research, which often bring into question the claims of linguists made on the basis of a second-hand written description. Very few Chadic languages have been looked at in this way, and I hope that this thesis will encourage more interest in this group of fascinating languages.

Bibliography

Abaglo Poovi and Diana Archangeli. 1989. Language-Particular Underspecification: Gengbe /e/ and Yoruba /i/. Linguistic Inquiry. 20: 457-480.

Abrahamson A. and L. Lisker. 1985. Relative power of cues: F0 shift versus voice timing. In (Ed.) V. A. Fromkin. Phonetic linguistics: essays in honor of Peter Ladefoged. Orlando. Academic Press. 25-33.

Ainsworth, W.A. and K.K. Paliwal. 1984. Correlation between the production and perception of the English glides /w, r, l, j/. Journal of Phonetics. 12: 237-243.

Aitchison, Jean. 2001. Language Change: progress or decay? CUP.

Akinlabi, Akinbiyi. 1996. Featural Affixation. Journal of Linguistics. 32: 239-289.

Akinlabi, Akinlabi & E. Urua. 1992. Prosodic targets and vocalic specification in Ibidio verbs. WCCFL. 11:1-14.

Alderete, John. 1996. Prosodic Faithfulness in Cupeño. In (Ed.) E. Benedicto. University of Massachusetts Occasional Papers in Linguistics 20, The Umass Volume on Indigenous Languages. [ROA-131-0496].

Alderete, John. 1999a. Morphologically Governed Accent in Optimality Theory. New York. Routledge. [ROA 309-0399].

Alderete, John. 1999b. Head dependence in stress-epenthesis interaction. In (Eds.) B. Hermans and M. van Oostendorp. The Derivational Residue in Phonological Optimality Theory. Linguistics Today. John Benjamins Publishing Company. Amsterdam. 29-50.

Alderete, John. 2001. Dominance Effects as Transderivational Anti-Faithfulness. Phonology. 18: 201-253.

Anderson, Stephen. C. and Jeanette Swackhamer. 1981. From consonants to downstep in Podoko. Studies in African Linguistics. 12: 131-153.

Applegate, Richard. 1971. Vowel Harmony in Chumash. Berkeley Papers in Linguistics. 1: 3-12.

Archangeli, Diana. 1984. Underspecification in Yawelmani phonology and morphology. Cambridge, MA. MIT.

Archangeli, Diana. 1988. Aspects of underspecification theory. Phonology 5: 183-207.

Archangeli, Diana. & Keiichiro Suzuki. 1997. The Yokuts challenge. In (Ed.) Iggy Roca. Derivations and Constraints in Phonology. Oxford. Clarendon Press.

Archangeli, Diana and Douglas Pulleyblank. 1989. Yoruba Vowel harmony. Linguistic Inquiry 20: 173-217.

Archangeli, Diana and Douglas Pulleyblank. 1994. Grounded Phonology. Cambridge. MA., MIT Press.

Archangeli, Diana & Douglas Pulleyblank. 2007. Harmony. In (Ed.) Paul de Lacy. The Cambridge Handbook of Phonology, Cambridge. CUP.

Awoyale, Yiwola. 2000. The Phonological Structure of Yoruba Ideophones. In (Eds.) H.E. Wolff and O. Gensler. Proceedings of the 2nd World Congress of African Linguistics, Leipzig 1997. Köln: Rüdiger Köppe. 293-309.

Avery, Peter and William Idsardi. 2001. Laryngeal dimensions, completion and enhancement. In (Ed.). T.Allen. Distinctive Theory. Berlin. Mouton de Gruyer. 41-70.

Avery, Peter and William Idsardi. Forthcoming. Laryngeal Phonology. CUP.

Bailey P.J. and M.P. Haggard. 1980. Perception-production relations in the voicing contrast for initial stops in 3-year-olds. Phonetica. 37: 377-396.

Baković, Eric. 1996. Foot Harmony and Quantitative Adjustments. Shorter version in Proceedings of WCCFL 15. [ROA-168-1296].

Baković, Eric. 2000. Harmony, dominance and control. PhD dissertation at New Brunswick, New Jersey. [ROA-360].

Bao, Zhi Ming. 1990. On the nature of tone. PhD dissertation at MIT.

Bao, Zhi Ming. 1999. The Structure of Tone. Oxford. OUP.

Barnes, Jonathan. 2006. Strength and Weakness at the Interface: Positional Neutralization at the Interface. Mouton de Gruyter.

Barreteau, Daniel. 1987. Du vocalisme en Tchadique. In (Ed.) Daniel Barreteau. Colloques et Séminaires: Langues et Cultures dans le bassin du lac Tchad. Paris. ORSTOM.

Barreteau, Daniel. 1995. Vowel and Tonal Variations within the Consonantal framework of the Verbal Stem in Central Chadic Lanuages. In (Eds.) Dymitr Ibriszimow, Rudolf Leger, Gerald Schmitt. Studia Chadica et Hamitosemitica: Akten des Internationalen Symposions zur Tscahsprachenforschung. Johann Wolfgang Goethe-Universität, Franfurt am Main, 6-8. Mai 1991. Köln. Rüdiger Köppe Verlag.

Barreteau, Daniel and Hermann Jungraithmayr, 1982. Le verbe en sibine. In (Ed.) Hermann Jungraithmayr, The Chad Languages in the Hamitosemitic-Nigritio Border Area. Berlin. Verlag Von Dietrich Reimer.

Beckman, Jill. 1997. Positional faithfulness, positional neutralization and Shona vowel harmony. Phonology 14: 1-46.

Beckman, Jill. 2003. Re-reevaluating Constraint Conjunction. Paper given at Manchester Phonology Meeting 11.

Beckman, Jill. 1997. Positional faithfulness, positional neutralization and Shona vowel harmony. Phonology 14: 1-46.

Beddor, Patrice, Rena Krakow, and Stephanie Lindemann. 2001. Patterns of Perceptual Compensation. In (Eds.) E. Hume and K. Johnson. The role of speech perception in phonology. San Diego. Academic Press.

Bermúdez-otero, Ricardo and April McMahon. 2006. English phonology and morphology. In (Eds.) Bas Aarts and April McMahon. The handbook of English linguistics. oxford: Blackwell. 382-410.

Bernstein, Lynne. 1983. Perceptual development for labeling words varying in voice onset time and fundamental frequency. J. Phonetics 11: 383-393.

Best, Cathi. 1995. A direct realist view of cross-language perception. In (Ed.) W. Strange. Speech Perception and Linguistic Experience: Issues in Cross-Language Research. Baltimore MD. New York Press.

Bethin, Christina 1998. Slavic prosody: language change and phonological theory. Cambridge. CUP.

Bickmore, Lee. 2003. The use of Feet to Account for Binary Tone Spreading. Evidence from Chilungu. In (Ed.) Rose-Juliet Anyanwu. Stress and Tone – The African Experience. Frankfurter Afrikanistische Blätter 15. Köln: Rüdiger Köppe Verlag.

Blevins, Juliette. 1993. A tonal analysis of Lithuanian nominal accent. Language 69. 237-273.

Blevins, Juliette. 1995. The syllable in phonological theory. In (Ed.) John Goldsmith. The Handbook of Phonological Theory. Massachusetts. Blackwells.

Blevins, Juliette. 2004. Evolutionary Phonology: The emergence of sound patterns. Cambridge. CUP.

Blevins, Juliette. 2006. Phonetically-based sound patterns: Typological tendencies or phonological universals? Ms presented at LabPhon 10, Paris, June 2006.

Blevins, Juliette. and A. Garrett. 1998. The origins of consonant-vowel metathesis. Language 74: 508-56.

Borroff, Marianne. 2007. A Landmark Underspecification Account of the Patterning of Glottal Stop. PhD dissertation at the State University of New York at Stony Brook. [ROA-1289].

Bradshaw, Mary. 1999. A Cross-Linguistic Study of Consonant-Tone Interaction. PhD Dissertation at Ohio State University.

Bradshaw, Mary. 2000a. Tone and its Phonological Interaction with Consonants. Tone Symposium, Tromso University.

Bradshaw, Mary. 2000b. Consonant-Tone Interaction in African Languages. In (Eds.) V. Carstens, F. Parkinson. Advances in African Linguistics. (Proceedings of the 28th Annual Conference on African Linguistics). Trends in African Linguistics 4. Trenton, NJ: Africa World Press.

Bradshaw, Mary. 2003. Consonant-tone interaction in Siswati. Studies in Phonetics, Phonology and Morphology. 9.2: 277-294.

Broselow, Ellen., Su-I Chen and Marie Huffman. 1997. Syllable Weight: Convergence of Phonology and Phonetics. Phonology 14: 47-82.

Browman, Catherine P. and Louise Goldstein. 1988. Some notes on syllable structure in Articulatory Phonology. Phonetica 45: 140-155.

Browman, Catherine P. and Louise Goldstein. 2000. Competing constraints on intergestural coordination and self-organization of phonological structures. Ms. Yale University.

Buckley, Eugene. 1997. Against vowel length in Tigrina. Studies in African Linguistics 26.1: 63-102.

Buckley, Eugene. 1998. Iambic Lengthening and Final Vowels. International Journal of American Linguistics 64.3: 179-223.

Buckley, Eugene. 1999. Uniformity in Extended Paradigms. In (Eds.) Ben Hermans and Marc van Oostendorp. The Derivational Residue in Phonological Optimality Theory. Linguistics Today. Vol. 28. John Benjamins Publishing Company. Amsterdam.

Bye, Patrik. 2004. Evolutionary typology and Scandinavian pitch accent. Kluwer Academic Publishers, Netherlands.

Byrd, Dani. 1996. Influences on articulatory timing in consonant sequences. Journal of Phonetics 24.2. Academic Press Ltd. 209-244.

Carnochan, Jack. 1988. The vowels of Hausa. In (Eds.) G. Furness and Philip Jagger. Studies in Hausa, Language and Linguistics: In honour of F.W.Parsons, London. Kegan Paul.

Casali, Roderic. F. 2003. [ATR] value asymmetries and underlying vowel inventory structure in Niger-Congo and Nilo-Saharan. Linguistic Typology 7: 307-382

Chambers, Jack. 1992. Dialect acquisition. Language 68: 673-705.

Chambers, Jack. 2003. Sociolinguistic Theory: Linguistic Variation and its Social Significance. Second edition. Blackwell.

Chebanne, A.M., Denis. Creissels, and H.W. Nkhwa. 1997. Tonal morphology of the Setswana verb. Munich, LINCOM. Europa.

Cheshire, Jenny. 2002. Sex and gender in variationist research. In (Eds.) J.K. Chambers, Peter Trudgill and Natalie Schilling-Estes. The Handbook of Language Variation and Change. Oxford. UK. Blackwell.

Chistovich, L.A. 1968/69 Variation of the fundamental Voice Pitch as a Discriminatory Cue for Consonants. In Soviet Physics - Acoustics 14: 372-378.

Clements, G.Nick. 2000. Phonology. In (Eds.) B. Heine and D. Nurse. African Languages: an Introduction. CUP. 123-160.

Cole, Jennifer and Charles Kissebirth. 1998. Restricting Multi-level Constraint Evaluation: Opaque Rule Interaction in Yawelmani Vowel Harmony. [ROA-98-0000].

Connell, Bruce. 2000. The perception of lexical tone in Mambila. Language and Speech. 163-182.

Crosswhite, Katherine. 2001. Vowel reduction in Optimality Theory: access, mobility, and resilience among urban Latino youth. New York. Routledge.

De Dominicis, Amedeo. 2003. Tone or Pitch Accent in Masa? In (Ed.) H. Ekkehard. Wolff. Topics in Chadic Linguistics. Papers from the 1st Biennial International Colloquium on the Chadic Languages, Leipzig, July 5-8, 2001. Köln. Rüdiger Köppe Verlag. 353-372.

Dehé, Nicole. 2004. On the order of objects in Icelandic double object constructions. In (Eds.) Ad Neeleman and Mary Pearce. UCL Working Papers in Linguistics 16. University College London.

de Lacy, Paul. 1999. Tone and Prominence. University of Massachusetts, Amherst. [ROA-298].

de Lacy, Paul. 2002. The interaction of tone and stress in Optimality Theory. Phonology 19: 1-32.

de Lacy, Paul. 2004a. Markedness conflation in Optimality Theory. Phonology 21: 123-199.

de Lacy, Paul. 2004b. Maximal Words and the Maori Passive. In (Ed.) John McCarthy. Optimality Theory in Phonology: A Reader. Blackwell Publishing. 495-512.

Den Os, Els and René Kager. 1986. Extrametricality and Stress in Spanish and Italian. Lingua 69: 23-48.

Derbyshire, Desmond. 1979. Hixkaryana. Lingua Descriptive Studies, no. 1. Amsterdam. North-Holland.

Diehl, Randy and Keith Kluender. 1989. On the objects of Speech Perception. Ecological Psychology. 1.2: 121-144.

Diehl, R., K. Kluender, M. Walsh. and E. Parker. 1991. Auditory enhancement in speech perception and phonology. In (Eds.) R. Hoffman and D. Palermo. Cognition and the symbolic processes: Applied and ecological perspectives. Hillside, NJ. Erlbaum. 59-75.

Downing, Laura. 2003. Stress, Tone and Focus in Chichewa and Xhosa. In (Ed.) Rose-Juliet Anyanwu. Stress and Tone – the African Experience. Frankfurter Africanistische Blätter 15. Köln. Rüdiger Köppe Verlag.

Dresher, B Elan and Aditi Lahiri (1991). The Germanic foot: Metrical coherence in Old English. Linguistic Inquiry 22: 251-286.

Duanmu, San. 1990. A Formal Study of Syllable, Tone, Stress and Domain in Chinese Languages. PhD dissertation at MIT.

Duanmu, San. 1992. An autosegmental analysis of tone in four Tibetan languages. Linguistics of the Tibeto-Burman Area. 15.1: 65-91.

Duanmu, San. 1993. Rime, length, stress and association domains. Journal of East Asian Linguistics 2.1: 1-44.

Duanmu, San. 1994. Syllable Weight and Syllabic Duration: A Correlation between Phonology and Phonetics. Phonology 11: 1-24..

Duanmu, San. 1997. Recursive constraint evaluation in optimality theory: evidence from cyclic compounds in Shanghai. NLLT 15.3: 465:508.

Duanmu, San. 1999. Metrical structure and tone: evidence from Mandarin and Shanghai. Journal of East Asian Linguistics. 8.1: 1-38.

Dupoux, E., K. Kakehi , Y. Hirose, C. Pallier and J. Mehler. 1999. Epenthetic vowels in Japanese: A perceptual illusion. Journal of experimental psychology: Human perception and performance. 25: 1568-1578.

Ebert, Karen. 1974. Partial vowel harmony in Kera. Studies in African Linguitics. Supplement 5: 75-80.

Ebert, Karen. 1975. Sprache und Tradition der Kera (Tschad). Teil I. Texte. Berlin: Reimer.

Ebert, Karen. 1976. Sprache und Tradition der Kera (Tschad). Teil II: Lexikon. Berlin. Reimer.

Ebert, Karen. 1977. Some Aspects of the Kera verbal system. Studies in African Linguistics. Supplement 7: 33-41.

Ebert, Karen. 1979. Sprache und Tradition der Kera (Tschad). Teil III. Grammatik. Berlin. Reimer.

Ebert, Karen. 2003. 'Come' and 'go' as discourse connectors in Kera and other Chadic languages. In (Eds.) Erin Shay and Uwe Seibert. Motion, Direction and Location in Languages: In honour of Zygmunt Frajzyngier. Typological Studies in Language. 56. Amsterdam and Philadelphia: Benjamins.

Edmondson, Jerold and John Esling. 2006. The valves of the throat and their fashioning in tone, vocal register and stress: laryngoscopic case studies. In (Eds.) Bert Remijsen and Vincent J. van Heuven. Special Issue of Phonology: Between Stress and Tone. Phonology 23.2: 157-192.

Eisner, Jason. 1997. Decomposing FootForm: Primitive constraints in OT. 1-29 [ROA-205].

Elenbaas, Nine and René. Kager. 1999. Ternary rhythm and the lapse constraint. Phonology 16.3.

Evans, Bronwen and Paul Iverson. 2006. Plasticity in vowel perception and production; A study of accent change in young adults. Paper given at the 149th meeting of the Acoustical Society of America, April 2005. JASA. 117.4: 2426.

Everett, Dan. 1996. Syllable integrity. University of Pittsburgh. [ROA-163].

Ewen, Colin and Harry van der Hulst. 2001. The phonological structure of words: an introduction, Cambridge textbooks in Linguistics. CUP.

Flege, James E. 1987. A critical period for learning to pronounce foreign languages? Applied Linguistics 8: 162-177.

Flege, James E. 1995. Second language speech learning: Theory, findings, and problems. In (Ed.) W. Strange. Speech Perception and Linguistic Experience: Issues in Cross-Language Research. Baltimore MD: New York Press.

Flege, James E. 1999. Age of learning and second language speech. In (Ed.) D. Birdsong Second Language Acquisition and the Critical Period Hypothesis. London. Lawrence Erlbaum Associates. 101-132.

Flege, James.E., Ocke-Schwen Bohn and Sunyoung Jang. 1997. The production and perception of English vowels by native speakers of German, Korean, Mandarin, and Spanish. Journal of Phonetics 25: 437-470.

Flemming, Edward. 1995. Auditory Representations on Phonology.. PhD dissertation at UCLA. Los Angeles.

Flemming, Edward. 2004. Contrast and Perceptual Distinctiveness. In (Eds.) B. Hayes, R. Kirchner, and D. Steriade. Phonetically based phonology. CUP.

Frieda Elaina.M., Amanda C. Walley, James E. Flege and Michael E. Sloane. 2000. Adults perception and production of the English Vowel /i/. Journal of Speech, Language and Hearing Research 43: 129-143.

Gafos, Adamantios. 1998. Eliminating Long-Distance Consonantal Spreading. NLLT. Kluwer Academic Publishers. 223-278.

Gafos, Adamantios. 2002. A Grammar of Gestural Coordination. NLLT. 20: 269-337.

Garrett, Andrew and Mark Hale. 1993. The phonetics and phonology of Grimm's and Verner's Laws. Paper presented at LSA Annual Meeting.

Gendrot, Cédric and Martine Adda-Decker. 2005. Impact of duration on F1/F2 formant values of oral vowels: an automatic analysis of large broadcast news corpora in French and German. Paper given at Interspeech Sept. 4-8, 2005, Lisbon.

Gendrot, Cédric and Martine Adda-Decker. 2006. Is there a universal impact of duration on formant frequency values of oral vowels?: An automated analysis of speech from eight languages. Poster presented at LabPhon 10, Paris, June 2006.

Gnanadesikan, Amalia. 1997. Phonology with ternary scales. PhD dissertation at the University of Massachusetts, Amherst.

Goldsmith, John. 1976. Autosegmental Phonology. PhD Dissertation at MIT.

Gordon, Matthew. 2002. A typology of contour tone restrictions. Studies in Language. 25.3: 423-462.

Gordon, Matthew. 2004. Syllable weight. In (Eds.) Bruce Hayes, Robert Kirchner, Donca Steriade. Phonetically Based Phonology. Cambridge. CUP.

Gordon, Raymond. Jr. (Ed.). 2006. Ethnologue: Languages of the World, Fifteenth edition. Dallas, Tex.: SIL International. [http://www.ethnologue.com/].

Green, Thomas and Michael Kenstowicz. 1995. The Lapse Constraint. [ROA-101].

Gussenhoven, Carlos. 2004. The Phonology of Tone and Intonation. Cambridge. CUP.

Haeri, Niloofar. 1987. Male/Female differences in speech: an alternative interpretation. In (Eds.) Keith Denning et al., Variation in Language. NWAV-XV at Stanford. Stanford, CA: Department of Linguistics, Stanford University. 173-182.

Haeri, Niloofar. 1996. The Sociolinguistic Market of Cairo: Gender, Class and Education. London: Kegan Paul International.

Haggard Mark, Stephen Ambler, and Mo Callow. 1970. Pitch as a voicing cue. JASA 47: 613-617.

Hall, Nancy. 2003. Gestures and Segments: Vowels Intrusion as overlap. PhD dissertation at the University of Massachusetts.

Hall, Nancy. 2004. Implications of vowel intrusion for a gestural grammar. Ms. Haifa University. [http://research.haifa.ac.il/~nancyh/vowelint.pdf].

Hall, Nancy. 2006. Cross-linguistic patterns of vowel intrusion. Phonology 23.3: 387-429.

Halle, Morris. 1962. Phonology in generative grammar. Word. 18: 54-72.

Halle, Morris and Stevens, Kenneth. 1971. A note on laryngeal features. Quarterly Progress Report, Research Laboratory of Electronics (MIT), 101: 198-213.

Halle, Morris and Jean-Roger Vergnaud. 1987. An essay on stress. Cambrige, Mass. MIT Press.

Hansson, Gunnar. 2001. Theoretical and Typological Issues in Consonant Harmony. PhD dissertation at the University of California, Berkeley, CA. [http://www.ai.mit.edu/projects/dm/featgeom/hansson-diss.pdf].

Hansson, Gunnar. 2004a. Long-distance voicing agreement: An evolutionary perspective. Proceedings of the 30th Annual Conference of the Berkeley Linguistics Society, Berkeley, CA. BLS. Reimer.

Hansson, Gunnar. 2004b. Tone and voicing agreement in Yabem. Paper given at WCCFL.

Harrington, Jonathan, Sallyanne Palethorpe, and Catherine Watson. 2000. Monophthongal vowel changes in Received Pronunciation: an acoustic analysis of the Queen's Christmas broadcasts. JIPA. 30.1/2: 63-78.

Harris, John. 1987. Non-Structure-Preserving Rules in Lexical Phonology: Southeastern Bantu Harmony. Lingua 73: 255-292.

Harris, John. 1990. Segmental complexity and phonological government. Phonology 7: 255-300.

Harris, John. 1994a. English Sound Structure. Oxford and Cambridge, Mass. Blackwell.

Harris, John. 1994b. Melodic agreement and underparsing in Kera harmony. Paper given at International Workshop on Phonological Structure. University of Durham, Sept. 1994.

Harris, John. 2003. Vowel Height. Course notes, handout 4, for Advanced Phonological Theory B, University College London.

Harris, John. & Geoffrey Lindsey. 1995. The elements of phonological representation. In (Eds.) J. Durand and Francis Katamba, Frontiers of Phonology: Atoms, Structures, Derivations. London. Longman. 34-79.

Harrison, Phil. 1997. The relative complexity of Catalan vowels and their perceptual correlates. UCL Working Papers in Linguistics 9. University College London.

Haudricourt, Andre. –G. 1954. De l'origine des tons en vietnamien. Journal Asiatique. 242: 68-82.

Hayes, Bruce. 1981. A Metrical Theory of Stress Rules. PhD dissertation at MIT. Distributed by the Indiana University Linguistics club.

Hayes, Bruce. 1985. Iambic and Trochaic Rhythm in Stress Rules. In (Eds.) M. Niepokuj et al. Proceedings of the XIth Annual Meeting of the Berkeley Linguistics Society. 429-446.

Hayes, Bruce. 1987. A Revised Parametric Metrical Theory. In (Eds.) J. McDonough and B. Plunkett. Proceedings of NELS 17. pp. 274-289.

Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. Linguistic Inquiry 20: 253-306.

Hayes, Bruce. 1995. Metrical stress theory: Principles and case studies. Chicago. Chicago University Press.

Hayes, Bruce. 1999. Compensatory lengthening in Moraic Phonology. In (Ed.) John Goldsmith. Phonological Theory: The Essential Readings. Blackwell.

Holt, Lori, Andrew Lotto and Keith Kluender. 2000. Influence of fundamental frequency on stop-consonant voicing perception: A Case of learned covariation or auditory enhancement? JASA 2001. 109.2: 764-774.

Hombert, Jean-Marie. 1978. Consonant types, vowel quality and tone. In Fromkin (Ed.) Tone: A linguistic Survey. New York: Academic Press. 77-112.

Hombert, Jean-Marie, John Ohala and William Ewan. 1979. Phonetic Explanations for the Development of Tones. Language 55.1: 37-58.

Hong, Sung-Hoon. 2002. Underspecification in Optimality Theory: Vowel Harmony in Classical Manchu. Studies in Phonetics, Phonology and Morphology. 8.2: 323-350.

Hoole, Phil, Suzanne Fuchs, and Klaus Dahlmeier. 2003. Interarticulator Timing in Initial Consonant Clusters. Paper given at Proceedings of the 6th International Seminar on Speech Production, Sydney, December 7-10, 2003.

House, Arthur. S. and Grant Fairbanks. 1953. The influence of consonant environment upon the secondary acoustical characteristics of vowels. JASA 25: 105-113.

Hualde, José Ignacio. 1989. Autosegmental and metrical spreading in the vowel-harmony systems of Northwestern Spain. Linguistics 27. 773-805.

Hubbard, Kathleen. 1995a. 'Prenasalised Consonants' and syllable timing: evidence from Runyambo and Luganda. Phonology 12: 235-256.

Hubbard, Kathleen. 1995b. Towards a theory of phonological and phonetic timing. In (Eds.) B.A. Connell and A. Arvaniti. Phonology and Phonetic Evidence: Papers in Laboratory Phonology IV. Cambridge. CUP. 168-187.

Hyman, Larry. 1973. The Role of Consonant Types in Natural Tonal Assimilations, In (Ed.) Larry Hyman. Consonant Types and Tone, Southern California Occasional Papers in Linguistics. Linguistics Program USC. LA. No 1.

Hyman, Larry (Ed.). 1973. Consonant types and tone. Southern California occasional papers in linguistics. Los Angeles. USC.

Hyman, Larry. 1985. A Theory of Phonological Weight. Dordrecht: Foris.

Hyman, Larry. 1988. Underspecification and vowel height transfer in Esimbi. Phonology 5: 255-273.

Hyman, Larry, 1998. Review of [Odden, David. 1996. The phonology and morphology of Kimatuumbi. The Phonology of the World's Languages, Oxford. Clarendon Press.] Language 74.1: 154.

Hyman, Larry. 2001a. Tone systems. In (Eds.) M. Haspelmath et al. Language typology and language universals: An international handbook. Berlin. Mouton de Gruyter. 2: 1367-1380.

Hyman, Larry. 2001b. Vowel harmony in Gunu. Studies in African Linguistics. 30.2: 149-170.

Hyman, Larry. 2002. Is there a Right –to-Left Bias in Vowel Harmony? Paper presented at the 9th International Phonology Meeting. Vienna, Nov. 1, 2002.

Hyman, Larry. 2003. 'Abstract' vowel harmony in Kàlɔ̀ŋ: a system-driven account. In (Eds.) P. Sauzet and A. Zribri-Hertz. Typologie des langues d'Afrique et universaux de la grammaire. Paris. L'Harmattan. 85-112. [http://linguistics.berkeley.edu/~hyman_kalong_VH_Paper.pdf].

Hyman, Larry. 2006. Word-Prosodic Typology. In (Eds.) Bert Remijsen and Vincent J. van Heuven. Special Issue of Phonology: Between Stress and Tone. Phonology 23.2: 225-257.

Hyman, Larry and Russell Schuh. 1974. Universals of tone rules: evidence from West Africa. Linguistic Inquiry. 5: 81-115.

Itô, Junko and Armin Mestor. 1998. Markedness and Word Structure: OCP Effects in Japonese. Ms. University of California, Santa Cruz. [ROA-255-0498].

Itô, Junko, Armin Mester and Jaye Padgett. 1995. Licensing and Underspecification in Optimality Theory. Linguistic Inquiry, 26:4, 571-613.

Iverson, Gregory and Joseph Salmons. 2003. Legacy Specification in the Laryngeal Phonology of Dutch. Journal of Germanic Linguistics. 15:1-26.

Jaggar, Philip and H.Ekkehard Wolff (Eds.) 2002. Chadic and Hausa Linguistics; Selected papers of Paul Newman with commentaries. Köln. Rüdiger Köppe Verlog.

James, Dorothy J. 1994. Word tone in a Papuan language: an autosegmental solution. Language and Linguistics in Melanesia 25: 125-48.

Jensen, John and Margaret Stong-Jensen. 2005. Foot, Word and Laryngeal Features in English and Icelandic. Proceedings of the 2005 annual conference of the Canadian Linguistics Association.

Jiang-King, Ping. 1996. An Optimality Account of Tone-Vowel Interaction in Northern Min. PhD dissertation at the University of British Columbia. [ROA-266].

Jiménez, Jesús and Maria-Rosa Lloret. Andalusian vowel harmony: Weak triggers and perceptibility. OCP4, Rhodes. [ROA 901-0207].

Jungwraithmayr, Herrmann. 1971. The Tangale vowel system reconsidered. Journal of African Languages. 28-33.

Jungraithmayr, Hermann and K. Shimizu. 1981. Chadic Lexical Roots. Vol II. Tentative Reconstruction, Grading and Distribution. Serie A: Afrika, Band 26. Berlin. Verlag Von Dietrich Reimer.

Kager, René. 1989. A Metrical Theory of Stress and Destressing in English and Dutch. Linguistic Models. Dortrecht. Foris.

Kager. René. 1994. Ternary Rhythm in Alignment Theory. [ROA-35].

Kager, René. 1995a. Metrical Theory of Word Stress. In (Ed.) John Goldsmith. The Handbook of Phonological Theory. Massachusetts. Blackwells.

Kager, René. 1995b. Review Article on Metrical Stress Theory: Principles and Case Studies. Phonology 12: 437-464.

Kager, René. 1999a. Optimality Theory. Cambridge Textbooks in Linguistics. CUP.

Kager, René. 1999b. Surface Opacity of Metrical Structure in OT. In (Eds.) Ben Hermans and Marc. van Oostendorp. The Derivational Residue in Phonological Optimality

Theory. Linguistics Today. Vol. 28. John Benjamins Publishing Company. Amsterdam. 207-246.

Kager, René. 2002. Rhythmic Directionality by Positional Licensing. [ROA-514].

Kaun, Abigail. 1995. The typology of Rounding Harmony. PhD dissertation at UCLA.

Kenstowicz, Michael and Charles Kisseberth. 1979. Generative Phonology. Orlando. Academic Press.

Kenstowicz, Michael. 1993. Evidence for metrical constituency. In Kenneth Hale and Samuel Jay Keyser, (Eds.). The view from Building 20: Essays in Linguistics in honour of Sylvain Bromberger. Cambridge, Mass. The MIT Press. 257-273.

Keyser, Samuel and Kenneth Stevens. 2001. Enhancement revisited. In (Ed.) Michael Kenstowicz. Ken Hale: A life in language. Cambridge, MA. MIT Press.

Keyser Samuel and Kenneth Stevens. 2006. Enhancement and Overlap in the Speech Chain. Language 82.1: 33-63.

Kidda-Awak, Mairo. 2003. Floating Tones in Tangale. In (Ed.) H. Ekkehard Wolff. Topics in Chadic linguistics: Papers from the 1st Biennial International Colloquium on the Chadic languages. Leipzig, July 5-8, 2001. Köln. Rüdiger Köppe Verlag.

Kikuchi, Seiichiro. 2000. Spanish Definite Article Allomorphy: A Correspondence Approach. Paper given at the 6th meeting of the Phonological Society of Japan at Chiba University on June 16th 2000.

Kingston, John and Randy Diehl. 1994. Phonetic knowledge. Language 70.3: 419-454.

Kingston, John. and D. Solnit. 1989. The inadequacy of underspecification. Proceedings of the North Eastern Linguistic Society. 19: 264-78.

Kiparsky, Paul. 1991. Catalexis. Ms. Standford University and Wissenschaftskolleg zu Berlin. Paper presented at EUROTYP workshop, Salzburg.

Kiparsky, Paul. 2004. Universals constrain change; change results in typological generalizations. Ms. Stanford University. [www.stanford.edu/~kiparsky/].

Kiparsky, Paul. & Pajusalu, K. 2003. Towards a typology of disharmony. Ms. Stanford University. [www.stanford.edu/~kiparsky/].

Kisseberth, Charles. 1984. Digo tonology. In (Eds.) G. N. Clements and John Goldsmith. Autosegmental studies in Bantu tone. Dordrecth: Foris Publications. 105-182.

Klamer, Marian. 1994. Kambera: a language of Eastern Indonesia. HIL Dissertations, 11. The Hague. Holland Academic Graphics.

Kraft, Charles. 1981. Chadic Wordlists, volumes 1, 2, 3. Serie A: Afrika. Berlin. Verlag von Dietrich Reimer.

Kurisu, Kazutaka. 2001. The Phonology of Morpheme Realization. PhD dissertation. University of California at Santa Cruz. [ROA-490-0102].

Labov, William. 1972. Sociolinguistic Patterns. Philadelphia. University of Pennsylvania Press.

Labov, William. 1990. The Intersection of sex and social class in the course of linguistic change. Language Variation and Change 2: 205-54.

Labov, William. 2001. Principles of Linguistic Change. Volume 2: Social factors. Oxford. Blackwell.

Ladefoged, Peter. 1973. The features of the larynx. Journal of Phonetics 1.1: 73-83.

Ladefoged, Peter. 1980. What are linguistic sounds made of? Language 56: 485-502.

Ladefoged, Peter. 2001. Vowels and Consonants. An introduction to the sounds of languages. Malden. Mass. Blackwell Publishers.

Ladefoged, Peter and M. Lindau, 1986. Variability of Feature Specifications. In (Eds.) J. Perkell, and D. Klatt. Invariance and variability in Speech Processes New Jersey. Lawrence Erlbaum Associates. 464-479.

Ladefoged, Peter and Ian Maddieson. 1996. The Sounds of the World's Languages. Oxford. Blackwell.

Lahrouchi, Mohamed. 2005. A propos de la vocalization des pluriels en afroasiatique. Exemples du berbère, sémitique, couchitique et tchadique. Paper presented at Colloquium of African Languages and Linguistics 35, Leiden, 29-31 August 2005.

Lea, Wayne A. 1973. Segmental and Suprasegmental Influences on fundamental frequency contours. In (Ed.) Larry Hyman. Consonant Types and Tone, Southern California Occasional Papers in Linguistics. Linguistics Program USC. LA. No 1.

Leben, William. 1973. Suprasegmental Phonology. PhD Dissertation at MIT.

Leben, William. 1978. The representation of tone. In (Ed.) Victoria Fromkin. A. Tone: A Linguistic Survey. New York. Academic Press. 177-220.

Leben, William. 1997. Tonal Feet and the adaptation of English borrowings into Hausa. Studies in African Linguistics 25: 139-154.

Leben, William. 2001. Tonal Feet. In (Eds.) Ulrike Gut and Dafydd Gibbon, Proceedings, Typology of African Prosodic Systems. Bielefeld Occasional Papers in Typology 1: 27-40.

Leben, William. 2003. Tonal Feet as Tonal Domains. In (Ed.) J. Mugane. Linguistic Typology and Representations of African Languages. Trends in African Linguistics 5. Africa World Press. 129-138.

Leitch, Miles. 2001. Low Vowel and [-ATR] Harmony Effects in 7-Vowel Niger Congo Languages. Ms. SIL.

Lenneberg. E. 1967. Biological foundations of language. John Wiley. New York.

Levin, Juliette. 1985. Evidence for ternary feet and implications for a metrical theory of stress rules. Ms. University of Texas at Austin.

Levin, Juliette. 1987. Between epenthesis and excrescence: what happens after redundancy rules. In (Ed.) M. Crowhurst. Proceedings of the West Coast Conference on Formal Linguistics, vol. 6: 187-201. Stanford: The Stanford Linguistic Association.

Levin, Juliette. 1988. Generating ternary feet. Texas Linguistic Forum. 29: 97-113.

Lieven, Elena. 1997. Variation in a crosslinguistic context. In (Ed.) D. I. Slobin. The Crosslinguistic Study of language Acquisition. Vol. 5, Mahwah, NJ. Erlbaum.

Lightfoot, David. 1998. The development of language: acquisition, change and evolution. Oxford. Blackwell.

Lisker, Leigh. and Arthur Abramson. 1964. A cross-linguistic study of voicing in initial stops: Acoustical measurements. Words. 20: 384-422.

Lombardi, Linda. 1991. Laryngeal features and laryngeal neutralization. PhD dissertation at the University of Massachusetts at Amherst.

Lombardi, Linda. 1999. Positional Faithfulness and Voicing Assimilation in Optimality Theory. NLLT. 17.2: 267-302.

Lombardi, Linda, 2003. Markedness and the typology of epenthetic vowels. Ms. University of Maryland at College Park. [ROA-578].

Lowes, Gwendolyn. 2006. Kurtoep Tone: Reflections on Diachrony. Paper presented at Typology of Tone and Intonation Europe 2, Berlin, 9th September 2006.

Maddieson, Ian. 1978. Tone effects on consonants. Journal of Phonetics 6: 327-344.

Maddieson, Ian. 1984. The effects on F0 of a voicing distinction in sonorants and their implications for a theory of tonogenesis. Journal of Phonetics 12: 9-15.

Malambe, Gloria. 2006. Palatalization and other non-local effects in Southern Bantu Languages. PhD dissertation at UCL, London.

Maran, L.R. 1973. On becoming a tone language: A Tibeto-Burman Model of Tonogenesis. In (Ed.) Larry Hyman. Consonant Types and Tone, Southern California Occasional Papers in Linguistics. Linguistics Program USC. LA. No 1.

Matisoff. James. 1973. Tonogenesis in Southeast Asia. In (Ed.) Larry Hyman, Consonant Types and Tone, Southern California Occasional Papers in Linguistics. Linguistics Program USC. LA. No 1. pp. 71-95.

Matisoff, James. 1999. Tibeto-Burman tonology in an areal context. In (Ed.) Shigeki Kaji, Proceedings of the Symposium Cross-Linguistic Studies of Tonal Phenomena: Tonogenesis, Typology, and Related Topics. Tokyo: Institute for the Study of Languages and Cultures of Asia and Africa, Tokyo University of Foreign Studies. 3-32.

Matteson, Esther. 1965. The Piro (Arawakan) language. Berkeley. University of California Press.

McCarthy, John. 1981. A Prosodic Theory of Non-concatenative Morphology. Linguistic Inquiry 12.3: 373-418.

McCarthy, John. 2004. Headed Spans and Autosegmental Spreading. [ROA-685].

McCarthy, John. 2006. Consonant harmony via correspondence: Evidence from Chumash. To appear in (Eds.) Leah Bateman, Adam Werle, Michael O'Keefe, and Ehren Reilly. Papers in Optimality Theory III, Amherst, MA: GLSA. [ROA-879-1006].

McCarthy, John and Alan Prince. 1986. Prosodic Morphology. [Reprinted in (Ed). John Goldsmith. Phonological theory, the essential readings. Massachusetts, Blackwell. 1999. 238-288.] [ROA-482].

McCarthy, John and Alan Prince. 1990a. Prosodic morphology and template morphology. In (Eds.) Eid, Mushira and John McCarthy. Perspectives on Arabic Linguistics II. Amsterdam and Philadelphia. John Benjamins. 1-54.

McCarthy, John and Alan Prince. 1990b. Foot and Word in Prosodic Morphology: The Arabic Broken Plural. NLLT. 209-283.

McCarthy, John and Alan Prince. 1995a. Faithfulness and Reduplicative Identity. In (Eds.) Jill Beckman, Laura Walsh Dickey and Suzanne Urbanczyk. University of Massachusetts Occasional Papers in Linguistics 18. Amherst, MA: GLSA. 249-384. [ROA-103].

McCarthy, John and Alan Prince. 1995b. Prosodic Morphology. In (Ed.) John Goldsmith. The Handbook of Phonological Theory Massachusetts: Blackwells.

McCarthy, John and Alan Prince 1999a. Prosodic Morphology. In (Ed.) John Goldsmith. Phonological Theory: The Essential Readings. Blackwell.

McCarthy, John and Alan Prince. 1999b. Faithfulness and identity in Prosodic Morphology. In (Eds.) René Kager, Harry van der Hulst and Wim Zonneveld. The Prosody-Morphology Interface. Cambridge. CUP. 218-309. [Excerts in (Ed.) John McCarthy. 2004. Optimality Theory in Phonology: A Reader. Malden, MA and Oxford. Blackwell.]

McCartney, Steve. 2001. Binary bases of ternarity. Poster given at NELS 32.

McMahon, April. 2003. Phonology and the Holy Grail. Lingua. 113: 103-115.

Mellander, Evan. 2000. A prosodic account of rhythmic shortening and stress in Central Slavik. Ms. McGill University.

Mellander, Evan. 2001. Quantitative Processes Without an Iambic/Trochaic Law. Paper at the 20th West Coast Conference on formal linguistics, University of Southern California, Feb. 23-25, 2001.

Mills, Roger. 1975a. Proto South Sulawesi and Proto Austronesian phonology. PhD dissertation at University of Michigan.

Mills, Roger. 1975b. The reconstruction of Proto South Sulawesi. Archipel 10: 205-24.

Moskovsky, Christo. 2001. The Critical Period Hypothesis Revisited. Proceedings of the 2001 Conference of the Australian Linguistic Society.

Muthwii, Margaret. 1994. Kalenjin in Kenya: the socio-phonological interaction of an ethnic language with English and Kiswahili. Language Forum 2.1: 1-48.

Newman, Paul. 1972. Syllable weight as a phonological variable. Studies in African Linguistics. [Reprinted in (Eds.) Philip Jaggar and Ekkehard Wolff. Chadic and Hausa Linguistics, 2002, Germany. Rüdiger Köppe Verlag.1-19.]

Newman, Paul. 1979. The Historical development of medial /ee/ and /oo/ in Hausa . Journal of African Languages and Linguistics 173-88. Köln. Rüdiger Köppe Verlog. [Reprinted in (Eds.) Philip Jagger and EkkehardWolff. Chadic and Hausa Linguistics; Selected papers of Paul Newman with commentaries. 2002.]

Newman, Paul. 2000. The Hausa Language: An Encyclopedic Reference Grammar. New Haven and London. Yale University Press.

Newman, Roxana Ma, and Vincent van Heuven. 1981. An acoustic and phonological study of pre-pausal vowel length in Hausa. Journal of Africal Languages and Linguistics 3: 1-18.

Odden, David. 1994. Adjacent parameters in Phonology. Language. 70.2: 289-330.

Odden, David. 2005. The Unnatural Tonology of Zina Kotoko. Submitted to the Proceedings of the TIE Conference, Santorini.

Ohala, John. 1973. The Physiology of Tone. In (Ed.) Larry Hyman. Consonant Types and Tone, Southern California Occasional Papers in Linguistics. Linguistics Program USC. LA. No 1.

Ohala, John. 1978. Production of tone. In (Ed.) Victoria Fromkin A. Tone: A Linguistic Survey. New York. Academic Press. 5-40.

Ohala, John. 1995. Experimental Phonology. In (Ed.) John Goldsmith Handbook of Phonological Theory. Oxford. Blackwell. 713-722.

Olanike-Ola, Orie. 1997. Benue-Congo Prosodic Phonology and Morphology in Optimality Theory. LINCOM Studies in African Linguistics 15. München-Newcastle. LINCOM Europa .

Olson, Kenneth and John Hajek. 2003. Crosslinguistic Insights on the Labial Flap. Linguistic Typology 7.2: 161.

Olson, Kenneth and John Hajek. 2004. A crosslinguistic lexicon of the labial flap. Linguistic Discovery, Vol. 2, Issue 2, Dartmouth College. [http://journals.dartmouth.edu/].

Padgett, Jaye. 2002. Feature classes in Phonology. Language 78: 81-110.

Parkinson, Frederick. 1996. The representation of vowel height harmony in phonology. PhD dissertation at Ohio State University.

Payne, Arvilla. 1998. Factors controlling the acquisition of the Philadelphia dialect by out-of-state children. In (Ed.) William Labov. Locating Language in Time and Space. New York. Academic Press. 143-78.

Pearce, Mary. 1999. Consonants and Tone in Kera (Chadic). Journal of West African Languages 27.1: 33-70.

Pearce, Mary. 2003. Vowel Harmony in Kera (Chadic). MA dissertation at University College London. [www.sil.org/africa/cameroon/index.html].

Pearce, Mary. 2005a. Iambicity without stress in Kera. CamLing 2005: Proceedings of the University of Cambridge Second Postgraduate Conference in Language Research. Cambridge Institute of Language Research.

Pearce, Mary. 2005b. Kera Tone and Voicing. In (Eds.) M. Pearce and N. Topintzi, UCL Working Papers in Linguistics. 17. Dept. of Phonetics and Linguistics, University College London.

Pearce, Mary. 2005c. Getting into a flap: Is the labiodental flap a phoneme in Kera? Poster in UCL Graduate School Poster Competition: Life Sciences winner.

Pearce, Mary. 2006a. The Interaction between metrical structure and tone in Kera. In (Eds.) Bert Remijsen and Vincent J. van Heuven. Special Issue of Phonology: Between Stress and Tone. Phonology 23.2: 259-286.

Pearce, Mary. 2006b. Evidence against voicing spread in Kera. In (Eds.) Richard Breheny and Mary Pearce, UCL Working Papers in Linguistics. 18. Dept. of Phonetics and Linguistics, University College London.

Pearce, Mary. 2006c. Enhancement between voice onset time (VOT) and F0: Evidence from Kera voicing perception. Paper given as invited speaker at special session on Enhancement and Multiplicity of Cues in Speech at the Acoustical Society of America, 151st Meeting. 2006. Rhode Island. JASA. 119.5: 3269.

Pearce, Mary. 2007a. Iambicity in Kera. Selected Proceedings of the 37th Annual Conference on African Linguistics, Cascadilla Press.

Pearce, Mary. 2007b. Evolving or revolving? Changes in a tone language. Poster in UCL Graduate School Poster Competition: Life Sciences joint-winner.

Pearce, Mary. To Appear. Kera voicing and tone interaction. Submitted to the Proceedings of the Tone and Intonation in Europe 2 (TIE2) Conference, ZAS Berlin, 7-9 Sept. 2006.

Penfield, Wilder and Lamar Roberts. 1959. Speech and Brain Mechanisms. Princeton University Press, Princeton.

Peng, Long 1992. A unified theory of tone-voice. PhD dissertation at the University of Arizona.

Peters, Ann. 1997. Language typology, prosody, and the acquisition of grammatical morphemes. In (Ed.) D. I. Slobin. The Crosslinguistic Study of language Acquisition. Vol. 5, Mahwah, NJ. Erlbaum.

Piggott, Glyne L. 1995. Epenthesis and Syllable Weight. NLLT 13. Kluwer Academic Publishers. 283-326.

Poser, William. 1981. On the directionality of the tone-voice correlation. Linguistic Inquiry 12: 483-88.

Preston, Dennis. 1989. Sociolinguistics and Second Language Acquisition. Oxford. Basil Blackwell.

Prince, Alan. 1980. A Metrical Theory for Estonian Quantity. Linguistic Inquiry. 11: 511-562.

Prince, Alan. 1983. Relating to the grid. Linguistic Inquiry 14. 19-100.

Prince Alan. and P. Smolensky 1993. Optimality Theory: Constraint Interaction in Generative Grammar. New Brunswick, NJ. Rutgers University Center for Cognitive Science. Technical report RuCCS-TR-2, [Reprinted in (Ed.) John McCarthy. Optimality Theory in Phonology: A Reader. 2004. Blackwell.] [ROA-537].

Prom-on Santitham, Yi Xu and Bundit Thipakorn (forthcoming). Quantitative Target Approximation Model: Simulating Underlying Mechanisms of Tones and Intonations. [www.phon.ucl.ac.uk/home/yi/research.html/].

Pulleyblank, Douglas. 1986. Underspecification and low vowel harmony. Studies in African Linguistics 1986. 17.2: 119-153.

Pulleyblank, Douglas. 1988. Vocalic Underspecification in Yoruba. Linguistic Inquiry 19: 233- 270.

Pulleyblank, Douglas. 1998. Yoruba vowel patterns: Deriving asymmetries by the tension between opposing constraints. [ROA-270-0798-07981].

Rennison, John. 1990. On the elements of phonological representations: The evidence from vowel systems and vowel processes. Folia Linguistica 24:175-244.

Rice, Curt. 1988. Stress assignment in the Chugach dialect of Alutiiq. In (Ed.) Lynn Macleod, Gary Larson and Diane Brentari. CLS 24: Papers from the 24th annual regional meeting of the Chicago Linguistic Society Chicago, IL: Chicago Ling. Soc. 304-315.

Rice, Curt. 1992. Binarity and ternary in metrical theory: Parametric extensions. PhD dissertation at the University of Texas at Austin. [http://www.hum.uit.no/a/rice].

Rice, Curt. 2006. The roles of Gen and Con in modelling ternary rhythm. Ms. [To appear in (Eds.) Sylvia Blaho, Patrik Bye and Martin Kramer Freedom of Analysis.]

Rice, Curt. 2007. As proud the head with heavy feet: Restrictions on structure are in Gen. Paper presented at OCP 4. Rhodes 2007.

Ringen, Catherine and Robert Vago. 1998. Hungarian vowel harmony in Optimality Theory. Phonology 15: 393-416.

Roberts, James. 2000. Accent clash in Mukulu verbs. Paper presented at the 22nd West African Languages Congress, Legon/Accra.

Roberts, James. 2001. Phonology of Central Chadic. In (Eds.) N. Mutaka and S. Chumbow Research Mate in African Linguistics: Focus on Cameroon. Köln: Rüdiger Köppe Verlag. 93-118.

Roberts, James. 2002. Phonological templates in Migaama verb structure. Paper given at the 9th International Phonology Meeting, University of Vienna, November 2002.

Roberts, James. 2005. Is Migaama a tonal or an accentual language? Poster presented at the Between Stress and Tone conference, University of Leiden, June 2005.

Rose, Sharon. and Rachel. Walker. 2004. A typology of consonant agreement as correspondence. Language. 80.3: 475-531.

Ruff, Joy. 2005. Phonology of Lagwan (Logone-Birni Kotoko). SIL, Cameroon. [www.sil.org/africa/cameroon/index.html].

Samek-Lodovici, Vieri. 1993. A unified analysis of crosslinguistic morphological germination. In (Eds.) Peter Ackema and Maaike Schoorlemmer. ConSole 1 proceedings. The Hague: Holland Academic Graphics. 265-283.

Sankoff, Gillian. 2002. Linguistic Outcomes of Language Contact. In (Eds.) J. K. Chambers, Peter Trudgill and Natalie Schilling-Estes. The Handbook of Language Variation and Change. Blackwell.

Schack Tang, Katrina. 2006. Voice-Tone Interaction in Bade. Paper given at TIE2, conference on tone and intonation, held at ZAS, Berlin, September 2006.

Schane, Sanford.A. 1990. Lowered height, laxness, and retracted tongue root: Different manifestations of phonological aperture. Word 41.1: 1-16.

Schuh, Russell. 1971. Towards a typology of Chadic vowel and tone systems. Ms.

Schuh, Russell. G. 1984. West Chadic Vowel correspondencies. In (Ed.) J. Bynon. Current Progress in Afro-Asiatic Linguistics Amsterdam. John Benjamins. 167-223.

Schuh, Russell. 2002a. Palatalization in West Chadic. Studies in African Linguistics 31: 97-128.

Schuh, Russell. 2002b. Bade/Ngizim Phonology and Morphology. Ms. Linguistics 252, Winter Quarter 2002. [http://www.humnet.ucla.edu/humnet/aflang/Bade/bade.html].

Schuh, Russell. 2003. Chadic Overview. In (Eds.) M.L. Bender, G Takacs and D.L. Appleyard. Selected Comparative-Historical Afroasian Linguistics Studies in memory of Igor M. Diakonoff. LINCOM Europa. 55-60.

Selkirk, Elisabeth. 1984. Phonology and Syntax: The Relation between Sound and Structure. Cambridge, MA. MIT Press.

Selkirk, Elisabeth. 1986. On Derived Domains in Sentence Phonology. Phonology Yearbook 3: 371-405.

Shryock, Aaron.M. 1995. Investigating Laryngeal Contrasts: An Acoustic Study of the Consonants of Musey. UCLA Working Papers in Phonetics 89.

Silva, David. 2006. Acoustic evidence for the emergence of tonal contrast in contemporary Korean. In (Eds.) Bert Remijsen and Vincent J. van Heuven. Special Issue of Phonology: Between Stress and Tone. Phonology 23.2: 287-308.

Silverman, Daniel. 1997. Phasing and recoverability. Outstanding dissertations in linguistics. ed. Laurence Horn. Garland Publishing. New York.

Silverman, Daniel. 2006. A Critical Introduction to Phonology: Of Sound, Mind and Body. Continuum.

Smith, Neil. 1967. The phonology of Nupe. Journal of African Languages. 6: 153-169.

Steriade, Donca. 1981. Parameters of metrical vowel harmony rules Ms. MIT.

Steriade, Donca. 1994. Positional neutralization and the expression of contrast. Ms. UCLA.

Steriade, Donca. 2000. Paradigm uniformity and the phonetics-phonology boundary. In (Eds.) Janet Pierrehumbert and M. Broe. Acquisition and the lexicon. Papers in Laboratory Phonology 5. CUP. 313-34.

Stevens, Kenneth. 1977. Physics of laryngeal behaviour and larynx modes. Phonetica 34: 264-279.

Stevens, Kenneth. 2003. Acoustic and Perceptual Evidence for Universal Phonological Features. In 15th ICPhS, Barcelona.

Stevens, Kenneth. 2006. Defining and enhancing attributes for features. Paper given as invited speaker at special session on Enhancement and Multiplicity of Cues in Speech at the Acoustical Society of America, 151st Meeting. 2006. Rhode Island.

Stolbova, Olga. 1996. Studies in Chadic Compartive Phonology. Diaphragma, Moscow.

Stolbova, Olga. 2005. Chadic Lexical Database. Issue 1. L, N, NY, R. Poligrafiya, Kaluga.

Strand, E. and K. Johnson. 1996. Gradient and visual speaker normalization in the perception of fricatives. In (Ed.) D. Gibbon. Natural Language Processing and Speech Technology. Berlin. Mouton. 14-26.

Suzuki, Keiichiro. 1998. A typological investigation of dissimilation. PhD dissertation at the University of Arizona.

Svantesson, Jan-Olof and David House. 2006. Tone production, tone perception and Kammu tonogenesis. In (Eds.) Bert Remijsen and Vincent J. van Heuven. Special Issue of Phonology: Between Stress and Tone. Phonology 23.2: 309-333.

Tourneux, Henry. 1978. Le mulwi ou vulum de Mogroum, Tchad: langue du groupe musgu, famille tchadique: phonologie, elements de grammaire. Paris: SELAF.

Tourneux, Henry. 2003. Le système consonantique des langues dites <kotoko>. In (Ed.) Ekkehard Wolff Topics in Chadic linguistics: Papers from the 1st Biennial International Colloquium on the Chadic languages. Leipzig, July 5-8, 2001. Köln. Rüdiger Köppe Verlag.

Truckenbrodt, Hubert. 1995. Phonological phrases: Their relation to syntax, focus, and prominence. PhD dissertation at MIT.

Trudgill, Peter. 1983. On Dialect: Social and Geographic Factors. Oxford. Basil Blackwell.

Trudgill, Peter. 1986. Dialects in Contact. Oxford. Basil Blackwell.

Uffmann, Christian. 2003. Optimal Geometries. In (Eds.) Marc. van Oostendoorp and Jeroen van de Weijer. The Internal Organization of Phonological Segments. Proceedings of Old World Conference in Phonology 1. Berlin/New York. Moutonde Gruyter.

Vaibra Nicholas. 2003. Essai de description du systeme verbal de «VUN HEDE» (langue Zime). Mémoire de Maitrise en linguistique. Université de N'Djaména, Chad.

Vaissière, Jacqueline. 1997. Phonological use of the larynx: a tutorial. Larynx 97. Marseille. 115-126.

van der Hulst, Harry and Jeroen van de Weijer. 1995. Vowel Harmony. In John Goldsmith. (Ed.) The Handbook of Phonological Theory Massachusetts: Blackwells.

van de Weijer, Jeroen. 2003 The Internal Organization of Phonological Segments. Proceedings of Old World Conference in Phonology 1. Held at Leiden, Jan. 10-12, 2003. Moutonde Gruyter. Berlin/New York.

van Oostendorp, Marc. 1999. Italian s-voicing and the structure of the phonological word. In (eds.) S.J. Hannahs and M. Davenport. Issues in phonological structure. Benjamins. 197-214.

Vogel, Irene. 1993. Phonological Interfaces in Italian. In (Ed.) M. Mazzola. Proceedings of Linguistics: Studies on Romance Languages XXIII.

Walker, Rachel. 1999. On the connection between round licensing, harmony and bisyllabic triggers in Altaic. [ROA-328-0699].

Walker, Rachel. 2000a. Long-distance Consonantal Identity Effects. In (Eds.) Bilerey and Lillehaugen. WCCFL 19 Proceedings. MA. Cascadilla Press. 532-545.

Walker, Rachel. 2000b. Nasalization, Neutral Segments and Opacity Effects. PhD dissertation at UC Santa Cruz. New York. Garland.

Walker, Rachel. 2001. Positional Markedness in Vowel Harmony. In (Eds.) Caroline Fery, Antony Dubach Green and Ruben van de Vijver. Proceedings of HILP5. Linguistics in Potsdam 12: 212-232.

Walker, Rachel. 2005. Weak Triggers in Vowel Harmony. NLLT. 23: 917-989.

Warner, N., A. Jongman, , A. Cutler and D. Mücke. 2001. The phonological status of Dutch epenthetic schwa. Phonology 18.3: 387-420.

Waterson, Natalie. 1971. Child Phonology: A prosodic view. Journal of Linguistics. 7:179-211.

Watkins, Justin. 2001. Pitch phonation correlations in Sgaw Karen. Ms.

Weidman, Scott and Sharon Rose. 2006. A foot-based reanalysis of edge-in tonal phenomena in Bambara. Paper presented at West Coast Conference on Formal Linguistics 25, University of Washington.

Whalen Douglas, Arthur Abrahamson, Leigh Lisker, and Maria Moody. 1990. Gradients effects of fundamental frequency on stop consonant voicing judgements. Phonetica l 47: 36-49.

Williams, Edwin. (1976). Underlying tone in Margi and Igbo. Linguistic Inquiry 7.3: 436-468.

Wiltshire, Caroline. 2003. Beyond Codas: Word and Phrase-Final Alignment. In (Eds.) Féry Caroline and Ruben van de Vijver.The Syllable in Optimality Theory. CUP. 254-268.

Wolff, Ekkehard. 1981. Reconstructing vowels in Central Chadic. In (Eds.) H. Meyer-Bahlburg and Ekkehard Wolff, Studies in Chadic and Afroasiatic Linguistics. Hamburg. Helmut Buske Verlaf.

Wolff, Ekkehard. 1987a. Consonant-tone interference in Chadic and its implications for a theory of tonogenesis in Afroasiatic. In (Ed.) Daniel Barreteau. Colloques et Séminaires: Langues et cultures dans le bassin du lac Tchad: Journées d'études les 4 et 5 septembre 1984. Paris. ORSTOM.

Wolff, Ekkehard. 1987b. Consonant-Tone Interference and Current Theories on Verbal Aspect Systems in Chadic Languages. Proceedings of the Fourth International Hamito-Semitic Congress. Amsterdam, John Benjamins. 451-474.

Wolff, Ekkehard (Ed.) 2001. Topics in Chadic Linguistics. Papers from the 1st Biennial International Colloquium on the Chadic Languages, Leipzig, July 5-8, 2001. Köhn. Rüdiger Köppe Verlag.

Wolfram, Walter. 1969. A Sociolinguistic Description of Detroit Negro Speech. Washington, D.C. Center for Applied Linguistics.

Wolfram, Walt, and Natalie Schilling-Estes. 1998. American English. Oxford. Blackwell.

Woods, Nicola. 1997. The formation and development of New Zealand English: Interaction of gender-related variation and linguistic change. Journal of Sociolinguistics 1. 95-126.

Xu, Yi. forthcoming. Speech as articulatorily encoded communication functions. Ms. UCL and Haskins Laboratories.

Xu, Yi. and fang Liu. in press. Tonal alignment, syllable structure and coarticulation: Towards an integrated model. Ms. [www.phon.ucl.ac.uk/home/yi/research.html].

Xu, Chung; Xu Yi and Li-Shi Luo. 1999. A pitch target approximation for F0 contours in Mandarin. Proceedings of the 14th ICPh in San Francisco. 2359-2362.

Xu, Yi and Xuejing Sun. 2000. How fast can we really change pitch? Maximum speed of pitch change revisited. Proceedings of the 6th International Conference on Spoken Language Processing. Beijing, 666-669.

Yip, Moira. 1980. The Tonal Phonology of Chinese. PhD dissertation at MIT. [Published 1990, New York. Garland Publishing].

Yip, Moira. 1988. Template Morphology and the direction of association. NLLT 6.4: 551-577.

Yip, Moira. 2002. Tone. Cambridge Textbooks in Linguistics. Cambridge, CUP.

Yoneda, Masato. 1993. Survey of standardization on Tsuruoka City, Japan: Comparison of results from three surveys conducted at twenty-year intervals. Paper presented at Methods VIII: International Conference in Dialectology. University of Victoria, British Columbia.

Yu, Alan. 2005. University of Chicago. Towards a Typology of Compensatory Reduction. In (Eds.) John Alderete et al. Proceedings of the 24th West Coast Conference on Formal Linguistics. Somerville, MA. Cascadilla Proceedings Project. 397-405.

Zec, Draga. 1999. Footed tones and tonal feet: rhythmic constituency in a pitch-accent language. Phonology 16: 225-264.

Zhiqiang Li. 2005. Dual Prominence in Tone Mapping: A Case of Tone Movement. In (Ed.) John Alderete et al. Proceedings of the 24th West Coast Conference on Formal Linguistics. Somerville, MA. Cascadilla Proceedings Project. 245-256.

Zoll, Cheryl. 2003. Optimal Tone Mapping. Linguistic Inquiry 34.2: 225-268.

Appendix 1

Inalienable nouns

A number of these have secondary meanings and these are listed in brackets. Where the root carries two tones, the second has been placed over the final consonant, but it is realised on the following vowel once the suffix has been added.

adìid- 'grandmother'
akáar- 'parent/child -in-law'
bàɩ́ 'father' (master)
cɩ́ɩ(r) 'head' (on)
dàar- 'friend'
dɩ̀gn- 'tail'
dɩ̀ɩ́ 'eye' (inside)
dɔ̀ŋr- 'back of neck'
dɔ̀rd- 'throat, voice'
gàby- 'cheeks'
gèlèrg- 'toe nails'
gèdɩ́- 'husband'
gɩ̀gɩ̀ɩr- 'knee'
gìid- 'stomach' (in/feelings)
gùud- 'backside' (behind)
kāmn- 'parents'
kāmpá 'feet' (distance/frequency)
kārm- (y) 'children' (small)
káas- 'arm, hand' (by)
kɛ́rk- 'back'
kɩ́ɩy- 'side, trunk'
kɩliŋ- 'testicles'
kīsīld- 'tongue'
kīsn- 'teeth'
kɔ̄rm- (y) 'son'
kɔ̄sn- 'ear' (leaf/page)
kú- 'mouth'
kúur 'neck'
kúsr- 'body' (person)
māan- 'co-wife'
māɩ́- 'wife'
nāar- 'aunt'
nāwɩ́- 'sister'
nɛ̄ɛr- 'sister-in-law'
nīin- 'nose'
nīɩ́- 'mother'
séen- 'brother'
sīrṕ- 'ribs'
tant- 'penis' (descendent)
tārḿ- (y) 'heart' (emotions)
táwr- 'tail'
tīin- 'forehead' (in front of)
tīɩ́- 'skin' (spirit)
tīrn- 'daughter'
tūŋkúd- 'shadow'

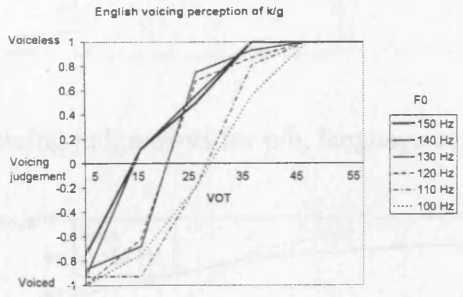
In addition to these words, there are about 40 'relative' nouns which do not change their form, but which are followed by the preposition [dɩ], which agrees with the number and person in the same way as the inalienable nouns above. A number of the inalienable nouns also have a related word that is a preposition.

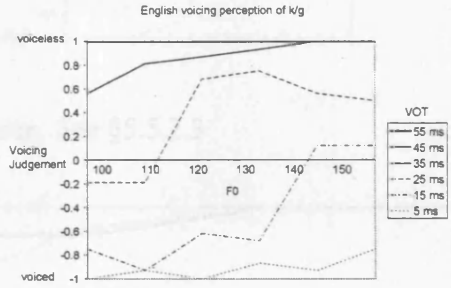
Appendix 2

Further VOT/F0 voicing judgement tests

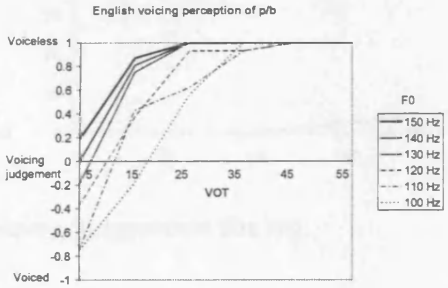
See chapter 5

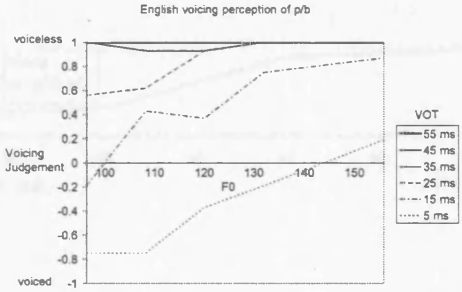
(1) Results of 16 English speakers for the k/g judgement test. See §5.5.2.1



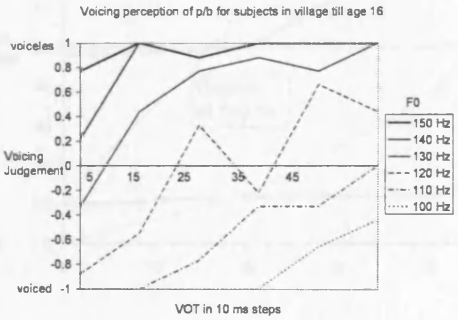


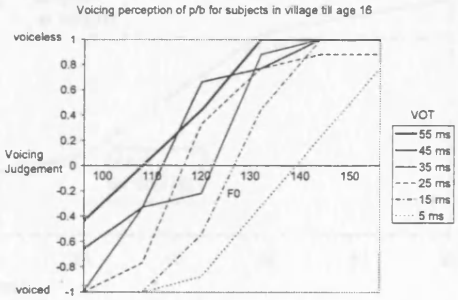
(2) Results of 16 English speakers for the p/b judgement test



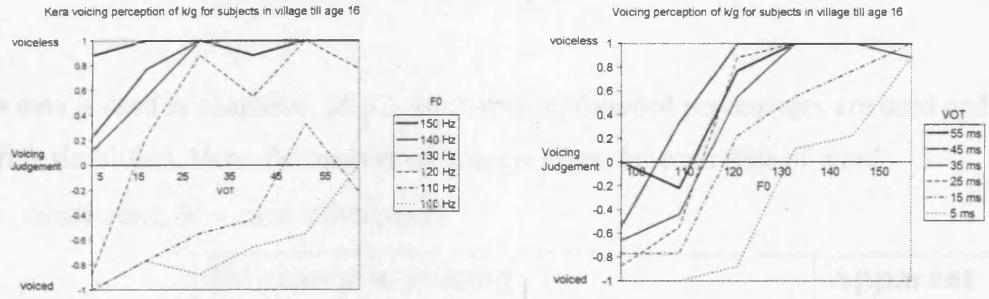


(3) Results of Kera speakers brought up in a village, for the p/b judgement test. See §5.5.2.2

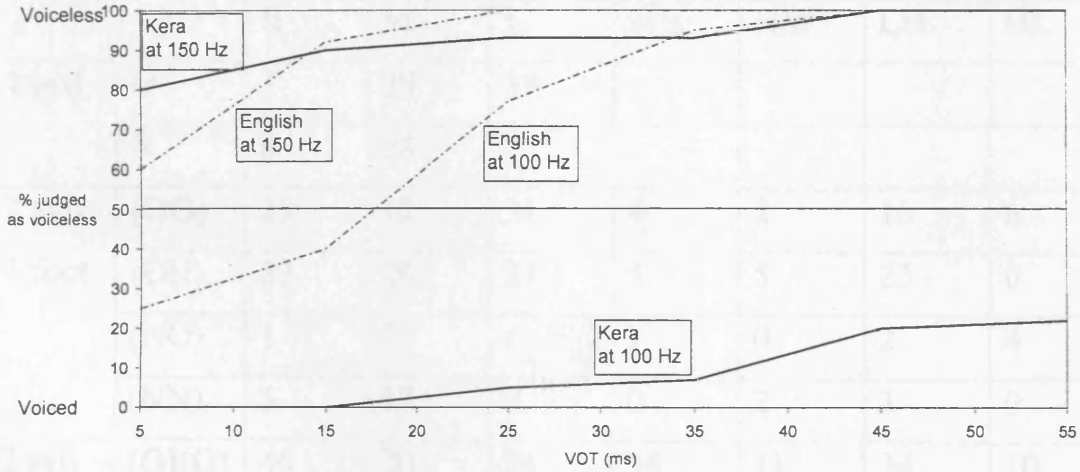




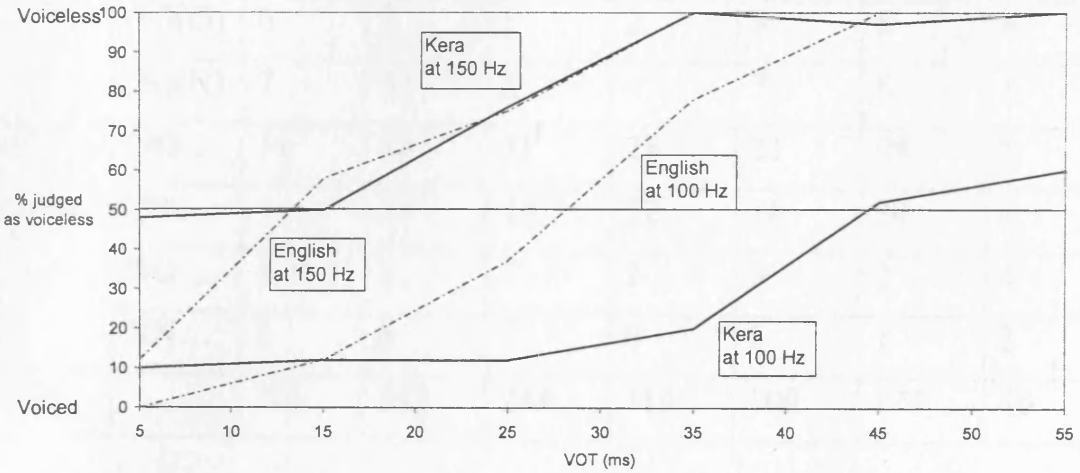
(4) Results of Kera speakers brought up in a village, for the k/g judgement test



(5) Voicing judgements for p/b, language comparison. See §5.5.2.3



(6) Voicing judgements for k/g



Appendix 3

Statistical analysis of lexicon

This data is used in chapter 6, §6.6.3. In chapter 6, rounded percentages are used and the chart is simplified. Here, the number of items is given for each type of word.

(O – obstruent, N – non-obstruent)

		No change in voicing					**Apparent voicing change**	
		H	M	L	MH	HM	LH	HL
1 syll	O	7	39	39				
	N	8	28	9				
2 syll 1 foot	**(OO)**	25	12	31	4	2	16	6
	(ON)	32	20	27	5	5	23	0
	(NO)	1	7	1	1	0	2	4
	(NN)	5	17	0	0	2	3	0
2 syll 2 feet	**(O)(O)**	46	20	24	34	11	34	10
	(O)(N)	46	40	35	20	15	34	2
	(N)(O)	6	2	3	2	8	8	4
	(N)(N)	7	22	5	4	7	6	1
>2 syll	**OO…**	11	18	31	25	21	24	5
	ON…	4	13	23	22	18	24	2
	NO…	1	6	7	2	3	2	4
	NN…	2	8	5	0	8	1	2
total		201	252	244	119	100	177	40

Appendix 4

Kera Folk Tale

This folk story has been slightly simplified and stylised. It was recorded from a town speaker who generally had only two tones, but sometimes a trace of three. The three contrasts were evident in the VOT lengths and tone combined. In the phonetic line here, I have chosen to show the contrast with three tones in the style of a village-to-town speaker. A VOT difference is also marked and short VOT is written as voicing. Slips of the tongue and hesitations are removed, but elision is kept. The aim is to give a typical rendition of the story rather than a recording of one telling. I have tried to be consistent in marking tone etc., but any errors are of course my own. It should be noted that when examples from this folk story are included in the main body of the thesis, the actual phonetic values are used rather than this stylised version. As with the rest of the thesis, certain conventions for Chadic languages are used rather than IPA, so <c> represents IPA [tʃ], <j> represents IPA [dʒ], <'> represents IPA [ʔ] and <y> represents IPA [j]. Underlying length is shown by repeated letters.

The **underlying form** is of course conjecture, but this line shows one possible form. Tones are placed on the first syllable of the foot which will be associated with that tone.

The **phonetic line** does not go into great detail, and short VOT is indicated by the voiced grapheme. Accents are used for tone. Length is indicated with one or two colons. A length of two colons is restricted to clause final position. a: means approximately 90 ms, a:: means approximately 130 ms or longer. In some of the examples below there is no lengthening at the end of the line because the speaker continued straight on to the next line. In other cases, even though there would not be a break in English, there is a clear pause in Kera and the lengthening is then marked.

The **parsing line** uses parentheses to show feet and right hand square brackets to mark phonological phrase boundaries when it is clear from the phonetics that the boundary is there. Although it seems likely that phonological phrases are aligned with the edges of XPs, boundaries are not marked if there are no phonetic cues. The details of the link with syntax is not explored here, but boundaries are marked where it helps to explain the reason for a break in the parsing. One-syllable function words cannot be heavy in general, so these sometimes act like a non-parsed syllable and this is the transcription used in these cases.

The **orthographic line** records the actual orthography which is in use among the Kera. Tone is marked only to distinguish between minimal pairs, with the marking on the high toned version. Voiced graphemes are used for short VOT. An apostrophe is used for the glottal stop. <o> and <e> cover both allophones of these vowels but <a> is

separated from the allophone <ə>. <ə> is also used for /ɨ/. Although this orthography is not perfect, it is used with ease by the 2000 Kera who have learnt to read it.

The folk story itself seems to originate from the Kera region, or possibly from a nearby group. It is a popular tale as can be seen from the fact that I have two recordings of it from different speakers – when they were free to tell me any story. The characters of squirrel and hyena have personalities that are well understood within story telling. Squirrel is clever while hyena is the cunning enemy that everyone wants to catch out.

The lines are arranged as follows:

1. Underlying Representation
2. Phonetic realisation
3. Parsing into feet
4. Orthography
5. Gloss
6. Free translation

Abbreviations

ACC	Accomplished (Perfect)
FOC	Focus
PERF	Perfective
EMPH	Emphatic
IMPER	imperative
HAB	Habitual

1

UR: **acùcun pìprim**
Phonetic: àjùjùn bìbrìm
Parsing: **a(jujun)(bib)(rim)**
Orthography: Ajujun bibrim

Gloss: ***folk-tale***
Free trans.: *Here is a story.*

2

UR: **tiikɨ́ kòlt-ŋ hél pɨ́ míntí hàrmɨ mɔ́**
Phon: tīikɨ́ gɔ̀ldɔ̀ŋ hɛ́l bɨ́ míntí hàrmmɔ́::
Pars: **(tii)kɨ] (gɔl)(dɔŋ)(hɛl)] (bɨmin)(tihar)(mɨmɔ:)**
Orth: Tiikə goldoŋ hel bə minti harmə mo

Gl: ***squirrel looked for wisdom of that what question***
Free: *Squirrel was looking for some way...*

3

UR: **tɔ́ cì tíniiní tɨ̀ kɔ̀rnɔy**
Phon: tó jì: tīníiní dɨ̀ gɔ̀rnɔ̀y
Pars: **(tɔji:)(tinii)ni] (dɨgɔr)(nɔy)**
Orth: Tó ji tiniini də Gornoy

Gl: ***he do trick of hyena***
Free: *to trick hyena.*

4

UR: **wɨ táar-a cɨ́ɨr pèké war-a nɛŋnɛŋ kɛɗɛ**

Phon: wɨ̄ táará: cɨ́r bègé: wār nɛ̄ŋnɛ̄ŋ kɛ̄ɗɛ̄::

Pars: **(wɨtaa)(ra:)(cɨr)(begɛ:)] (war)(nɛŋ)(nɛŋ)(kɛɗɛ:)**

Orth: Wə taaraŋ cəərə begeŋ wəra neŋneŋ kɛɗɛ

Gl: ***he gathered head animals ACC all all***

Free: he gathered together all the animals.

5

UR: **anɨ ákàparnáw mál-ŋ kùut-u cɨ́ɨr akàparnáw-a**

Phon: ānák bàrnáw (pause) māláŋ gùudù cɨ́ɨrɨ́: kə́bàrnəwà::

Pars: **(anak)(bar)(naw)] (məlaŋ)(guu)du] (cɨɨ)(rɨ:)(kəbar)(nəwa:)**

Orth: Anə kəbarnaw məlaŋ guudu cəərə kəbarnawa

Gl: ***group ants placed behind head ants***

Free: The ants started with the ants,

6

UR: **haa war-na cɨ́ɨr ana pàaŋa na**

Phon: hāa wārnə̄ cɨ́ɨrā: nə̄ bàaŋə̀ nā::

Pars: **(haa)(war)(nəcɨɨ)(ra:)(nəbaa)(ŋəna:)**

Orth: Haa warna cəərə anə baaŋa na

Gl: ***until over-there head group elephant there***

Free: right up to the elephants.

7

UR: **wɨ káa saama kúur pèké-ŋa**

Phon: wɨ̄ káa sāamā kúr bègŋá::

Pars: (wɨkaa)(saa)ma] (kur)(bɛg)(ŋa:)

Orth: Wə kaŋ saama kuurə begeŋaŋ,

Gl: ***he threw rope neck the animals***

Free: He tied rope round the neck of the animals.

8

UR: **wɨ káa-ní saama-ŋ kúur-i kaya ta pɨ̀ mɔŋ**

Phon: kɨ̄ɨ̄nī sāamāŋ kúurí kəyā: tɨ̄bɨ̀mɔ̀ŋ

Pars: **(kɨɨ)(nisaa)(maŋ)(kuu)ri] (kəya:)tɨ(bɨmɔŋ)**

Orth: wə kəəni saamaŋ kuuri kəya tə bə moŋ,....

Gl: ***he threw the rope their necks there emph. of SUB. cl***

Free: Having tied the rope round their necks,

9

UR: **wɨ fàa-n-y a kul pɔ̀plɔ́ alɨwa**

Phon: vɨ̀ɨ̀nɨ̀y àkūl bɔ̀blɔ́ ᵃlɨ̄wā::

Pars: **(vɨɨ)(nɨy)] (akul)(bɔb)lɔ] (lɨwa:)**

Orth: wə vəənəy a kuli boblo aləwa.

Gl: ***he sent them house big inside***

Free: He sent them inside a big house.

10

UR: **kùut saama tɨ́ míntí kúur pɛ̀kɛ́-ŋa, wɨ yáak-t-nu war-a**

Phon: gùd sāamə̄ míntí kúr bɛ̀gŋá wɨ̄ yáktɨ́nɨ́y wə̄rà::

Pars: **(gud)(saa)(məmin)(tikur)(bɛg)ŋa] (wɨyak)(tɨnɨy)(wəra:)**

Orth: Gud saamaŋ də minti kuurə begeŋa, wə yaktənəy wəra

Gl: ***base-of rope that neck the-beasts he left-each-of-them ACC***

Free: Because of the rope around the animal's necks, he left them alone.

11

UR: **wɨ tiilima wara làm làm làm làm làm làm làm**

Phon: wɨ̄ tīilīmā: wār làm làm làm làm làm làm làm

Pars: **(wɨtii)(lima:)(war)(lam)(lam)(lam)(lam)(lam)(lam)(lam)**

Orth: Wə tiilima wəra lam lam lam lam lam lam lam

Gl: ***he outside ACC laying-down, laying-down...***

Free: He was outside, laying down the ropes beside each other.

12

UR: ana aŋa wɨ pɨ tár-tɛ tɨ kúur pèké-ŋa alɨwa na

Phon: ā:nāaŋā: bɨ tárté dɨ kúr bègé:ŋāa lɨ̄wnā::

Pars: (a:)(naa)(ŋa:)(bɨtar)tɛ] (dɨkur)(begɛ:)(ŋaa)(lɨw)(na:)

Orth: Anaaŋa wə bə tarte də kuurə begeŋa aləwna

Gl: but it each-one dress of neck the-beasts inside

Free: But they were also attached around the animal necks inside.

13

UR: tiikí ráaw-ŋ káyá-ŋ wɨ kàa saama móɔtɔ kúur kìwkìw

Phon: tīikí ráawáŋ káyáŋ (pause) wɨ̄ gàa sāamə̄ móɔtɔ̄:: (pause) kúurɨ̄ gìwgìwī::

Pars: (tii)kɨ] (raa)(waŋ)(kəyaŋ)] (wɨgaa)(saa)(məmɔɔ)(tɔ:)] (kuu)(rɨgiw)(giwi:)

Orth: Tiikə raawaŋ kəyaŋ, wə gaŋ saama mooto kuurə giwgiwi

Gl: squirrel continued then he threw rope big neck bat

Free: *At this point Squirrel put a big rope around a bat's neck*

14

UR: wɨ ís-ŋ pɨ waat-ŋ káa-ŋ fad minti hàrmɨ mɔ́

Phon: wɨ̄ɨ̄ síŋ wāatāŋ káŋ fādī: míntí hàrmì mɔ́:

Pars: [(wɨɨ)(siŋ)(waa)(taŋ)(kaŋ)(fadī:)(min)(tihar)(mɨmɔ:)

Orth: Wə əsəŋ bə waateŋ kaŋ fadī minti harmə mo

Gl: he started of speaking people simply that what question

Free: Then he said to the people...

15

UR: hèpkána ha'-ŋ kùut saama war-a làmlàm tiilim-aŋ

Phon: hèbkə́ná a'āŋ (pause) gùd sāamā: wār làm làm tīilīmàŋ

Pars: (hɛb)(kənaa)('aŋ)] (gud)(saa)(ma:)(war)(lam)(lam)(tii)(limaŋ)

Orth: « Hebkəna ha'aŋ, gud saama wəra lam lam tiilimaŋ

Gl: now then behind rope ACC laing-down here outside

Free: *'Now then, parts of these ropes are lying down outside*

16

UR: **A pɨ́ tár-tɛ áre kúur pɛ̀ké-ŋa aliwa-na**

Phon: ā: bɨ̀ tártér kúr bègé:ŋāa lɨ̄wnā::

Pars: **(a:)(bɨtar)(tɛr)(kur)(begɛ:)(ŋaa)(lɨw)(na:)**

Orth: A bə tarə-tere are kuurə begeŋa aləwa na

Gl: ***she is tied around us necks animals inside there***

Free: *They are tied to the necks of animals that are inside*

17

UR: **sám-a tɛn waat-ŋ war-a**

Phon: sə́má: tɛ̄n wāatāŋ wərà::

Pars: **(səma:)(tɛn)(waa)(taŋ)(wəra:)**

Orth: Səma ten waataŋ wəra

Gl: ***but I say-to-you ACC***

Free: But I'm telling you...

18

UR: **tam tɔ́ŋ ŋám-ŋ saama nɨmti né-ŋ**

Phon: tām tɔ́ŋ ŋə́máŋ sāamə̄ nɨ̄mtī nɛ̄ŋ

Pars: **(tam)(tɔŋ)(ŋəmaŋ)(saa)(mənɨm)ti] (nɛŋ)**

Orth: Tam toŋ ŋəmaŋ saama nəmti neŋ

Gl: ***you that-one chose rope yours perf.***

Free: If you choose your rope...

19

UR: **tam tád-ɛ war-a tà kay-a tà-ŋ ha'-ŋ**

Phon: tām téɗ wār dà: kāy dàŋ hā'āŋ

Pars: **(tam)(tɛd)(war)(da:)(kay)(daŋ)(ha'aŋ)**

Orth: Tam teɗe warda kaydaŋ ha'aŋ

Gl: ***you pull out here this here then***

Free: and you pull it to here....

20

UR: pàl-ŋ nɛ́ a saama-ŋa a cɨ̀-ŋ haa kúur-ŋa

Phon: bəlàŋ ná: sāamā: ŋāa jɨ̀ŋ hāa kúurəŋà::

Pars: (bəlaŋ)(naa)(saa)(ma:)(ŋaa)(jɨŋ)(haa)(kuu)(rəŋa:)

Orth: bəlaŋ neŋa saamaŋa a jəŋ haa kuurəŋa

Gl: wanted PERF to the-rope had ACC FOC the-neck

Free: if it happens that the rope that was around the neck...

21

UR: kúur-u kùukúr-a

Phon: kúurú gùugūrá::

Pars: (kuu)(ruguu)(gura:)

Orth: kuurə guugura

Gl: neck chicken

Free: ... the neck of a chicken,

22

UR: tam háme kùukúr nɨmti tam màna

Phon: tām hám gùugúr nɨ̄mtī tām mənà

Pars: (tam)(ham)(guu)(gur)(nɨm)ti] (tam)(məna)

Orth: tam hame guugur nəmti, tam məna

Gl: you eat chicken yours you one

Free: you will have to eath it all to yourself.

23

UR: tam tɔ́ŋ táɗ-ŋ nɛ́-ŋa saama pɨ kúur pàaŋa

Phon: tām tɔ́ŋ təɗáa nɛ́ŋá: sāamā: bɨ kúr bàaŋà::

Pars: (tam)(tɔŋ)(təɗaa)(nɛŋa:)(saa)(ma:)(bɨkur)(baa)(ŋa:)

Orth: Tam toŋ təɗaŋ neŋa saama bə kuurə baaŋaŋ

Gl: you there pulled PERF rope of neck elephant

Free: If you happen to pull on the rope around elephant's neck,

24

UR: yɨ pì càm-m̀ pàaŋa

Phon: yɨ̄ bì: jəmàm bàaŋà:

Pars: (yɨbi:)(jəmam)(baa)(ŋa:)

Orth: yə bə jəmam baaŋaŋ

Gl: they CONT cut-for-you elephant

Free: they will butcher the elephant for you.

25

UR: tam hám-ɛ pàaŋa haa tam màn-a'

Phon: tām hám bàaŋà hāa tām màn'ì::

Pars: (tam)(ham)(baa)ŋa] (haa)(tam)(man)('i:)

Orth: Tam hame baaŋa haa tam məna'i

Gl: you eat elephant FOC you one

Free: you will have to eat the whole elephant by yourself

26

UR: tam tɔ́ pàl-ŋ nɛ́ tɨ̀ hɔ́ɓ

Phon: tām tɔ́ bəlàa nē dɔ̄: ɓī::

Pars: (tam)tɔ] (bəlaa)(nedɔ:)(ɓi:)

Orth: Tam toŋ bəlaŋ ne də hɔɓi

Gl: you this wanted PERF of bad thing

Free: If you have bad luck,

27

UR: tam tád-ŋ nɛ́-ŋa saama pɨ́ míntí haa maa mɔ́ kúur haa tɛ tɛ tɛ

Phon: tām tə́ɗáŋ néŋá: sāamā bɨ́ míntí hāa māa mɔ́: kúurāa tɛ̄: tɛ̄: tɛ̄::

Pars: (tam)(tə́ɗaŋ)(neŋa:)(saa)ma] (bɨmin)(tihaa)(maa)(mɔ:)(kuu)(raa)(tɛ:)(tɛ:)(tɛ:)

Orth: Tam tə́ɗaŋ neŋa saamaŋ bə minti haa maa mo kuurə haa tee tee tee

Gl: you pulled PERF rope of that FOC what question neck FOC insects....

Free: If you pulled the rope attached to insects necks,...

28

UR: yɨ kúur akàparnáw-a

Phon: yɨ kúurá: gəbàrnə́wá::

Pars: (yɨkuu)(ra:)(gəbar)(nəwa:)

Orth: Yə kuurə akəbarnawa

Gl: they neck ants

Free: if they are around the necks of ants,

29

UR: tam hám-ŋ kár kɨ nɨmti kùut pɨ míntí hàrmɨ mɔ́

Phon: hámáŋ kár kɨ̄ nɨ̄mtī: (pause) gùd bɨ̀ míntí hàrmɨ̀ mɔ́::

Pars: (hamaŋ)(kar)(kɨnɨm)(ti:)] (gud)(bɨmin)(tihar)(mɨmɔ:)

Orth: tam hameŋa kar kə nəmti gud bə minti harmə mo

Gl: you eat things of yours behind of that what question

Free: you eat whatever is yours because...

30

UR: tam tɔ̀ɔ pàaŋa pà

Phon: dɔ̀ɔ bàaŋá: bà:

Pars: (dɔɔ)(baa)(ŋa:)] (ba:)

Orth: Tam doŋ baaŋa ba

Gl: you grabbed elephant not

Free: you didn't grab the elephant

31

UR: A mɔ́ŋ kùut pɨ míntí hàrmɨ mɔ́ tam ŋám-ŋ túuní pà

Phon: ã: mɔ́ŋ gùd bɨ̀ míntí hàrmɨ̀ mɔ́:: (pause) ŋə́máŋ túuní: bà:

Pars: (a:)(mɔŋ)(gud)(bɨmin)(tihar)(mɨmɔ:)] (ŋəmaŋ)(tuu)(ni:)] (ba:)

Orth: A moŋ gud bə minti harmə mo tam ŋəmaŋ tuuni ba.››

Gl: to question behind of that what question you chosen hippo not

Free: neither have you chosen the hippo!'

32

UR: **A kɔ́ tɔ́-ŋa káya ta pɨ́ mɔ**

Phon: ā: kɔ́: tɔ́ŋá: kəyá: tɨ̄ bɨ́ mɔ̄:

Pars: **(a:)(kɔ:)(toŋa:)(kəya:)tɨ(bɨmɔ:)**

Orth: A ko toŋa kəya tə bə mo,

Gl: ***at place that then EMPH of question***

Free: *At this moment*

33

UR: **ana aŋa tiikɨ́ waat-ŋ káa fad̰**

Phon: à:náaŋá:: tīikɨ́ wāatāŋ káa fād̰ī:

Pars: **(a:)(naa)(ŋa:) (tii)kɨ] (waa)(taŋ)(kaa)(fad̰)i:**

Orth: anaaŋa tiikə waataŋ kaa fad̰ī

Gl: ***this-then squirrel spoke people directly***

Free: *Squirrel said to them...*

34

UR: **àŋ ísk-ŋ nɛ́ pà mɔ́**

Phon: àŋ 'ískɨ́ɨné bəmɔ́::

Pars: **(aŋ)('ɨs)(kɨɨ)nɛ] (bəmɔ:)**

Orth: ‹‹ Aŋ əskəŋ ne bə moŋ? ››

Gl: ***you understood PERF not question***

Free: *'You have understood haven't you?'*

35

UR: **kɔ̀rnɔy míntí nɨin tin tam fáak lá**

Phon: gɔ̀rnɔ̀y míntí nɨ̄ndɨ̀n tām fáakál

Pars: **(gɔr)(nɔy)(min)ti] (nɨn)(dɨn)(tam)(faa)(kal)**

Orth: Gornoy minti: ‹‹ Nəənə dən tam faakə la

Gl: ***hyena that my uncle you rest IMPER***

Free: *Hyena said 'Uncle, relax!*

36

UR: tam kày-ŋ war-a tam fáak lá máŋ

Phon: tām gəyàŋ wərā tām fáakál máŋ

Pars: (tam)(gəyaŋ) wəra (tam)(faa)(kal)(maŋ)

Orth: Tam gəyaŋ wəra tam faakə la máŋ

Gl: you tired ACC you rest IMPER now

Free: You are tired, rest now!

37

UR: tɛn tɛ̀ pàlam tɨ kɛl a káa-ŋ

Phon: tɛ̄n dɛ̀: bəlàm dɨ̀ kɛ̄l 'ākáŋ

Pars: (tɛn)(dɛ:)(bəlam)(dɨkɛl)('akaŋ)

Orth: Ten de bəlam də kel a kaŋ ››

Gl: I grab trace of message to the-people

Free: *I will explain things to the people'*

38

UR: apɨ waat-a kɛl kìlá, a táy-ŋ saama mɔ́ɔtɔ-ŋ ana kay ɗàw

Phon: āpɨ̄ wāatā: kɛ̄l gìláa təyáŋ sāamə mɔ́ɔtɔ̄ŋ] ānkāy ɗàw

Pars: (apɨ)(waa)(ta:)(kɛl)(gila:)(təyaŋ)(saa)(məmɔɔ)(tɔŋ)] (an)(kay)(ɗaw)

Orth: A bə waataŋ kel gila, a təyaŋ saama mootoŋ anəkay ɗaw.

Gl: she is speaking message standing, she trod rope big like-this contra-expectation

Free: But while he was explaining to them, he had already stood on the big rope.

39

UR: a ɗɨ̄k-ŋ naata haa saama mɔ́ɔtɔ aŋa kúur pàaŋa

Phon: ādɨ̄ kɨ́nāatā: hāa sāa mə mɔ́ɔtō' ā:ŋà:: (pause) kúr bàaŋà::

Pars: (aɗɨ̄)(kɨnaa)(ta:)(haa)(saa)(məmɔɔ)(to'a:)(ŋa:)] (kur)(baa)(ŋa:)

Orth: A ɗəkəŋ naata haa saama mootoŋa a kuurə baaŋa

Gl: she thought her FOC rope big is neck elephant

Free: He thought that the big rope must be round the neck of the elephant.

40

UR: **anɨ aŋa tiikí kàa-nɨ haa kúur kìwkìwi**

Phon: ānāaŋā: tīikí gàanɨ̀ hāa kúurɨ̄:: (pause) gìwgìwī::

Pars: **[(anaa)(ŋa:)(tii)kɨ] (gaa)nɨ] (haa)(kuu)(rɨ:)] (giw)(giwi:)**

Orth: Anaaŋa tiikə gaanə haa kuurə giwgiwi

Gl: ***But in reality squirrel threw-it FOC neck bat***

Free: But squirrel had put it round the neck of the bat!

41

UR: **A háraŋ pɨ̀ tɔ̀k-ɛ kɛ́l pɨ̀ míntí tiikí waat-n-y war-a a káa fad̩**

Phon: ā háráŋ bɨ̀ dɔ̀k kɛ́l bɨ̀ míntí tīikí: wɨ̄ɨ̄tīnɨ̄y wərā: káa fādì::

Pars: **(aha)(raŋ)(bɨdɔk)(kɛl)(bɨmin)(titii)(kɨ:)(wɨɨ)(tɨnɨy)(wəra:)(kaa)(fad̩)(i::)**

Orth: A haraŋ bə dokte kel bə minti tiikə waatənəy wəra a kaa fad̩i

Gl: ***she returned to repeat message of that squirrel had said ACC to people directly***

Free: He repeated Squirrel's message to the people

42

UR: **Míntí tɛn waat-ŋ ha'-ŋ**

Phon: míntí tɛ-n wāatāŋ hā'áŋ

Pars: **(min)(titɛn)(waa)(taŋ)(ha'aŋ)**

Orth: Minti: ‹‹ Ten waataŋ ha'aŋ,

Gl: ***that I say-to-you this***

Free: he said 'I say this to you...

43

UR: **nɨin tɨ̀n waat-ŋ kɛ́l pɨ̀tɔɔna pád̩ak**

Phon: nɨ̄ndɨ̀n wāatāŋ kɛ́l bɨ̀dɔ̀n pád̩kī::

Pars: **(nɨn)(dɨn)] (waa)(taŋ)(kɛl)] (bɨdɔn)(pad̩)(ki:)**

Orth: nəənə dən waataŋ kel bədoona pəd̩aki

Gl: ***my uncle spoke message like this light***

Free: my uncle spoke clearly.

44

UR: **àŋ pɨ̀ tèy-ŋa míntí bà-ŋa-ŋ**

Phon: àŋ bɨ̀ dèyŋà míntí: bəŋàŋ

Pars: **(aŋ)(bɨdɛy)ŋa] (min)(ti:)(bəŋaŋ)]**

Orth: Aŋ bə deyeŋa minti bəŋaŋ

Gl: ***you arrive it that this***

Free: *You now say that*

45

UR: **káman lèn-ŋa mɔ́ káman wal-ŋa haa náan mɔ́-ŋa**

Phon: kə́mán lə̀ŋà: mɔ́ kə́mán wālŋāa náaní mɔ́:ŋā::

Pars: **(kəman)(ləŋa:)mɔ] (kəman)(wal)(ŋaa)(naa)(nɨmɔ:)(ŋa:)**

Orth: Kəman leneŋa mo kəman waleŋa haa naanə moŋa

Gl: ***certain-thing lost question certain-thing joy FOC how question***

Free: *the message is not clear, how can you say that?*

46

UR: **kɛl kɨ lí-u paapa a tɔŋ-a ta'a pà**

Phon: kɛ̄l kɨ̄líw pāapāa tōŋā: tā'ā: bà::

Pars: **(kɛl)(kɨlɨw)(paa)(paa)(toŋa:)(ta'a:)(ba:)**

Orth: Kel kə ləw paapa a toŋa ta'a ba

Gl: ***message of tripping-up not to this here not***

Free: *The message has nothing in it to trip you up*

47

UR: **wɨ waat-ŋ míntí tam tɔ́ŋ tádɛ-ŋ saama nɨmti né-ŋ**

Phon: wɨ̄ wāatāŋ míntí: tām tɔ́ŋ tə́ɗáŋ sām nɨ̄mtī: néŋ

Pars: **(wɨwaa)(taŋ)(min)(ti:)(tam)(tɔŋ)(tədaŋ)(sam)(nɨm)(ti:)(nɛŋ)**

Orth: Wə waataŋ minti tam toŋ tə́ɗaŋ saama nəmti neŋ

Gl: ***he said that you there one pulled rope yours PERF***

Free: *He said that if you pull on your rope...*

48

UR: **pàl-ŋ né-ŋa tam tɔ̀ŋ né-ŋa**

Phon: bəlàa néŋā:: (pause) tām dɔ̀ɔnéŋā::

Pars: **(bəlaa)(neŋa:)] (tam)(dɔɔ)(neŋa:)**

Orth: bəlaŋ neŋa tam doŋ neŋa

Gl: ***wanted PERF you grabbed PERF.....***

Free: *if it happened that you were to grab...*

49

UR: **saama tɨ́ kúur apìitíwpìitíw**

Phon: sāamā dɨ̀kúr bìidíwbìidíw

Pars: **(saa)ma] (dɨkur)(bii)(diw)(bii)(diw)**

Orth: saama də kuurə abiidiwbiidiw

Gl: ***rope of neck dragonfly***

Free: *the rope round the neck of the dragonfly,*

50

UR: **tam hám-ɛ apìitíwpìitíw nɨmti yaŋ**

Phon: há:mé: bìidíwbìidíw nɨ̄mtī yāŋ

Pars: **(ha:)(mɛ:)(bii)(diw)(bii)(diw)(nɨm)ti] (yaŋ)**

Orth: tam hame abiidiwbiidiw nəmti yaŋ

Gl: ***you eat dragonflies yours will***

Free: *...you will eat dragonflies!*

51

UR: **tam ŋém-ɛ hùlum pɨ́ míntí hàrmɨ mɔ**

Phon: tām ŋém hùlùm bɨ́ míntí hàrmɨ̀mɔ̄:

Pars: **(tam)(ŋem)(hulum)(bɨmin)(tihar)(mɨmɔ:)**

Orth: Tam ŋeme hulum bə minti harmə mo

Gl: ***you choose man of that what question***

Free: *Do not choose the man that...*

52

UR: káas-u áw-ŋ kúur pàaŋa pà

Phon: kɨ́ɨsú wáŋ kúr bàaŋá: bà::

Pars: (kɨɨ)(suwaŋ)(kur)(baa)(ŋa:)(ba:)

Orth: kəəsu awaŋ kuurə baaŋa ba

Gl: his-hand fell neck elephant not

Free: ...got the elephant!

53

UR: tam ŋém-ɛ hùlum pɨ míntí hàrmɨ mɔ́-ŋ

Phon: tām ŋém hùlùm bɨ míntí hàrmɨ̀mɔ́ŋ

Pars: (tam)(ŋɛm)(hulum)(bɨmin)(tihar)(mɨmɔŋ)

Orth: Tam ŋeme hulum bə minti harmə moŋ

Gl: you choose man of that what question

Free: You choose the man that....

54

UR: káas-u áw-ŋ cɨ́ɨr-u túuní-ŋ haa míntí wɨ áy-m̀ lá ŋanáaní mɔ́?

Phon: kɨ́ɨsú wáŋ cúr túuníŋ hī míntí wɨ̄: 'āyām lɔ́ ŋá:náaní: mɔ́::

Pars: (kɨɨ)(suwaŋ)(cur)(tuu)(niŋ)] (hɨmin)(tiwɨ:)('ayam)(ləŋa:)(naa)(nɨ:)(mɔ:)

Orth: kəəsu awaŋ cuuru tuuniŋ haa minti wə ayam leŋa naanə mɔ?

Gl: his-hand fell on hippo FOC that he gives you IMPER how question

Free: ...got the hippo so that he gives it to you, how is that?

55

UR: tam hàr-ɛ pɨ mánt-ɛ kúskí-ŋa káas-u, wɨ paapa

Phon: tām hàr bɨ mánté: kúskíŋā: kɨ́ɨsú:: (pause) wɨ̄ pāapā::

Pars: (tam)(har)(bɨman)(tɛ:)(kus)(kiŋa:)(kɨɨ)(su:)] (wɨpaa)(pa:)

Orth: Tam hare bə mante kuskiŋa kəəsu, wə paapa.

Gl: you return to asking meat his hand it not

Free: You return to ask him for meat? No way!

56

UR: **haa hɔ́ɓ nɨmti**

Phon: hāa hɔ́ɓ nɨ̄mtī::

Pars: **(haa)(hɔp)(nɨm)(ti:)**

Orth: Haa hoɓi nəmti

Gl: ***FOC luck yours***

Free: *It's just your bad luck!*

57

UR: **tɛn waat-ŋ war-a pɨ̀tɔɔna fad̩**

Phon: tɛ̄n wāatāŋ wərā: bɨ̀dɔ̀n fàd̩

Pars: **(tɛn)(waa)(taŋ)(wəra:)(bɨdɔn)(fad)**

Orth: Ten waataŋ wəra bədɔɔna fad̩i.››

Gl: ***I spoke ACC like-this directly***

Free: *This is what I have to say'*

58

UR: **tɨ̀ pɨ̀ míntí kampár-a táy-ɛ saama mɔ́ɔtɔ-ŋa ta pɨ̀ mɔŋ**

Phon: dɨ̀ bɨ̀ míntí kāmpár táy sāamə mɔ́ɔtɔ̄ŋā tɨ̄ bɨ̀ mɔ̄ŋ

Pars: **(dɨbɨ)(min)(tikam)(par)(tay)(saa)(məmɔɔ)(tɔŋa)tɨ(bɨmɔŋ)**

Orth: Də bə minti kampara teye saama mootoŋa tə bə moŋ

Gl: ***of of that foot tread rope big EMPH of question***

Free: *When he (hyena) stepped on the rope,*

59

UR: **tiikɨ́ míntí àŋ kàm-ɛ tɨ̀ kár ta pɨ̀ mɔŋ?**

Phon: tīikɨ́ míntí (pause) àŋ gàm dɨ̀ kár tɨ̄ bɨ̀ mɔ̄ŋ

Pars: **(tii)kɨ] (min)ti] (àŋ)(gam)(dɨkar)tɨ(bɨmɔŋ)**

Orth: Tiikə minti: ‹‹ Aŋ game də kar tə bə moŋ? ››

Gl: ***squirrel that you choose of thing EMPH of question***

Free: *Squirrel said 'have you chosen something?'*

60

UR: **wɨ hàraŋ tɨ táɗ-ŋ saama mɔ́ɔtɔ hɨ̀ɗɨ̀t!**

Phon: wɨ̄ hà:ràŋ dɨ́ tə́ɗáŋ sāamə̄ mɔ́ɔtɔ̄: hɨ̀ɗɨ̀t

Pars: **(wɨha:)(raŋ)dɨ(tə́ɗaŋ)(saa)(məmɔɔ)(tɔ:)(hɨɗɨt)**

Orth: Wə haraŋ də tə́ɗaŋ saama mooto hə́ɗə̀t!

Gl: ***he returned of pulling rope big jump***

Free: He (squirrel) yanked on the big rope.

61

UR: **kɔ̀rnɔ̀y ɗál-ŋ tiikɨ́ faɗ míntí hàrmɨ mɔ**

Phon: gɔ̀rnɔ̀y ɗə́láŋ tík fāɗ míntí hàrmɨ̀ mɔ̄:

Pars: **(gɔr)(nɔy)(ɗəlaŋ)(tik)(faɗ)(min)(tihar)(mɨmɔ:)**

Orth: Gornoy ɗəlaŋ tiikə faɗî minti harmə mo

Gl: ***hyena began squirrel simply that what question***

Free: Hyena immediately confronted squirrel...

62

UR: **saama náaya tá tɨ àpláw làm naŋ**

Phon: sāamə̄ náytá: dàbláw làm nāŋ

Pars: **(saa)(mənay)(ta:)(dab)(law)(lam)(naŋ)**

Orth: ‹‹ Saama naaya tá də ablaw lam naŋ

Gl: ***rope others them of lots sitting there***

Free: 'There are lots of other ropes!

63

UR: **tam pɛ̀l-ɛ ŋɛ́m-ɛ tá pɨ mɔ́?**

Phon: tām bɛ̀l ŋɛ́m tá: bɨmɔ́::

Pars: **(tam)(bɛl)(ŋɛm)(ta:)(bɨmɔ:)**

Orth: Tam bele ŋeme tá bə mɔ?

Gl: ***you want choose this-one of question***

Free: *Why do you want this one?*

64

UR: **ta káy-aŋ kát-ṇ, tɛn tèl-ɛ haa ta kɨ̀m**

Phon: tā: kə́yáŋ kátṇ tɛ̄n dèl hāa tɨ̄ gɨ̀m

Pars: **(ta:)(kəyaŋ)(katṇ)(tɛn)(dɛl)(haa)(tɨgɨm)**

Orth: Tá kəyaŋ katən, ten dele haa tá gəm

Gl: ***she there mine I start FOC EMPH she also***

Free: It's mine, so I will start with it'

65

UR: **a hàm-a fad, a ís-ŋ bɨ́ tád-a**

Phon: ā: hàm fād í:síŋ bɨ́ tə̄dā::

Pars: **(a:)(ham)(fad)(i:)(siŋ)bɨ(tədɑ:)**

Orth: A hama fadì, a əsəŋ bə tədɑ

Gl: ***she picks it up immediately, she starts to pull-it***

Free: He (hyena) picked it up and started to pull it.

66

UR: **a móŋ, àŋ sɛ̀ɛ lá war-a**

Phon: ā móŋ (pause) àŋ zɛ̀l wār

Pars: **(a mɔŋ)] (aŋ)(zɛl)(war)**

Orth: A moŋ: ‹‹ Aŋ zɛɛ la wəra

Gl: ***she question you move-away IMP ACC***

Free: He said 'Move back!

67

UR: **tɛn tád-ɛ kát-ṇ war-a kɨ̀m àŋ tɛ́dɛ kát-ṇ war-a kɨ̀m**

Phon: tɛ̄n tɛ́d kə́tán wār gɨ̀m āŋ tɛ́d kə́tán wār gɨ̀m

Pars: **(tɛn)(tɛd)(kətan)] (war)(gɨm)(aŋ)(tɛd)(kətan)] (war)(gɨm)**

Orth: Ten tedɛ kətan wəra kəm aŋ tedɛ kətan wəra gəm.››

Gl: ***I pull mine ACC first, you pull mine ACC also***

Free: *I'll pull mine first, you pull mine too.'*

68

UR: **a ɗɛ́-ŋ táɗ-ɛ war-a-tà kay tà-ŋ**

Phon: āɗɛ́ŋ táɗ wārdə̀ kāydàŋ

Pars: **(aɗɛŋ)(taɗ)(war)(dəkay)(daŋ)**

Orth: A ɗeŋ a teɗe warda kaydaŋ

Gl: ***she started to pull out there***

Free: *He pulled out…*

69

UR: **a ɗɨ́k-ŋ naata míntí tá téɗ-ɛ wara dà-ŋa**

Phon: ā ɗɨ́:kɨ́ŋ nāatā: míntí tá: téɗ wārdə̀ŋà::

Pars: **(aɗɨ:)(kɨŋ)(naa)(ta:)] (min)(tita:)(teɗ)(war)(dəŋa:)**

Orth: A ɗəkəŋ naata minti tá teɗe wardaŋa

Gl: ***she thought her that she pull out***

Free: *He thought that he would pull out…*

70

UR: **pàaŋa mɔ́? túuní mɔ́?**

Phon: bàaŋɨ̀ mɔ́: túuní mɔ́::

Pars: **(baa)(ŋɨmɔ:)(tuu)(nimɔ:)**

Orth: Baaŋa mo? Tuuni mo?

Gl: ***elephant question, hippo question***

Free: *maybean elephant or maybe a hippo.*

71

UR: **a ɗɛ́ŋ kɔ̀l-ŋa tɔ̀klɔ́y, a táɗ-a war-a tà haa-ŋa saama-ŋa kúur kìwkiw**

Phon: ā ɗɛ́ŋ gɔ̀lŋà: dɔ̀klɔ́y ā: təɗá: wār də̀ hāaŋā (pause) sāamə̀ŋā: kúr gìwgìw

Pars: **(aɗɛŋ)(gɔl)(ŋa:)(dɔk)(lɔy)(a:)(təɗa:)(war)(dəhaa)ŋa] (saa)(məŋa:)(kur)(giw)(giw)**

Orth: A ɗeŋ a goloŋa dogloy, a təɗaŋ warda haaŋa saaməŋa kuurə giwgiwi

Gl: ***she went look unexpectedly she pulls-it out here FOC rope neck bat***

Free: *He went to look, but what he pulled out was...the rope around the bat!*

72

UR: **a hùm-ŋ ku tɔ́rlɔ́ŋ kìl fad̩**

Phon: ā: hùmùŋ kū: tɔ́rlɔ́ŋ gìl fàdì::

Pars: **(a:)(humuŋ)(ku:)(tɔr)(lɔŋ)(gil)(fad̩)(i::)**

Orth: A humuŋ ku torloŋ gil fadi

Gl: ***she gathered mouth rapidly upright simply***

Free: *He stopped on the spot*

73

UR: **ana apìitíwpìitíw, pèké (n)áayáw tɔ́ŋ**

Phon: ānā abìidíwbìidíw (pause) bègé: yáwtɔ̄ŋ

Pars: **(anaa)(bii)(diw)(bii)(diw)] (begɛ:)(yaw)(tɔŋ)**

Orth: Anə abiidiwbiidiw, bege naayaw toŋ

Gl: ***group dragonfly animal other that***

Free: *The dragonflies, those other animals,*

74

UR: **wɨ d̩ɛ́ tád̩-ɛ nuutu war-a tà kay tàŋ**

Phon: wɨ̄ d̩ɛ́: téd̩ nūutū wārdə̀ kāydàŋ

Pars: **(wɨd̩ɛ:)(ted̩)(nuu)tu] (war)(dəkay)(daŋ)**

Orth: Wə d̩e ted̩e nuutu warda kaydaŋ

Gl: ***he went pull his out there***

Free: *Hepulled out of there.*

75

UR: **yɨ tád̩-ɛ maa aŋa, wɨ áw-ɛ kɨ́ɨs-u aŋa kúur pàaŋa**

Phon: téd̩ māaŋā (pause) wáw kɨ́ɨsá: ŋā: kúr bàaŋà::

Pars: **(ted̩)(maa)ŋa] (waw)(kɨɨ)(sa:)(ŋa:)] (kur)(baa)(ŋa:)**

Orth: Yə ted̩e maa aŋa, wə awe kəəsu aŋa kuurə baaŋa

Gl: ***they pull what like he falls his-hand like neck elephant***

Free: *They (dragonflies) pulled and got an elephant.*

76

UR: anɨ apárlaŋkay, a áw-ta káas aŋa apárlaŋkay áw-ta aŋa

Phon: ānā apárlāŋkāy (pause) 'áwtá: kə́s āanā apárlāŋkáwtáaŋā::

Pars: (anaa)(par)(laŋ)(kay)] ('aw)(ta:)(kəsaa)(naa)(par)(laŋ)(kaw)(taa)(ŋa:)

Orth: Anə aparlaŋkay, a awta kas aŋa aparlaŋkay awta aŋa

Gl: group lizards she falls-them hands like lizard falls-them like

Free: As for the lizards, their hands fell on...

77

UR: kúur túuní aŋa kàɗ faɗ

Phon: kúr túuní ŋā: gàɗ fàɗì::

Pars: (kur)(tuu)(niŋa:)(gaɗ)(faɗ)(i:)

Orth: kuurə tuuni aŋa gaɗì faɗì

Gl: neck hippo like exact simply

Free: ...the hippo.

78

UR: kɛl a waat-ŋ wara, a tam mɔ́ɔrɨ pɨtà kɨ̀m

Phon: kɛ̄l ā wāatāŋ wərā: (pause) ā: tām mɔ́ɔrɨ̄: pɨ̄:də̀ gɨ̀m

Pars: (kɛl)(awaa)(taŋ)(wəra:)] (a:)(tam)(mɔɔ)(rɨ:)(pɨ:)(dəgɨm)

Orth: Kel a waataŋ wəra: ‹‹Ãã tam moorə pəda gəm!››

Gl: message was said ACC yes you grumble no-more also

Free: Someone said, 'Yes, don't grumble any more!'

79

UR: kɔ̀rnɔy tɔ̀ɔ-ŋ naatá-ŋ kaya ta, kìwkìwi-ŋ kaya tà

Phon: gɔ̀rnɔ̀y dɔ̀ŋ nāatáŋ kāytā:: gìwgìwìŋ kāydà::

Pars: (gɔr)(nɔy)(dɔŋ)(naa)(taŋ)(kay)(ta:)] (giw)(giwiŋ)(kay)(da:)

Orth: Gornoy doŋ naataŋ kəya ta, giwgiwiŋ kayda.

Gl: hyena grabbed the-other then EMPH bat there

Free: Hyena grabbed the bat for herself.

80

UR: **a hɨɨ-nu apɨ́ya anɨ kay, a kùl-nu cáwa anɨ kay**

Phon: ā hɨɨnù pɨ́yá anɨ̄kāy (pause) ā: gùlnù: cə́wá anə̄kāy

Pars: **(ahɨɨ)nu] (pɨyaa)(nɨkay)] (a:)(gul)(nu:)(cəwaa)(nəkay)**

Orth: A həənu apəya anəkay, a gulnu cəwa anəkay

Gl: ***She lifted it up like this she looked it sun like this***

Free: He lifted it up and looked at the sun through it.

81

UR: **a míntí kát-ṇ tɔ́ haa náanaan pad̃aw**

Phon: ā míntí: (pause) kə́tán tɔ́ hāa náanán pə̄d̃āw

Pars: **(amin)(ti:)] (kətan)(tɔhaa)(naa)(nan)(pəd̃aw)**

Orth: A minti: ‹‹ Katən tó haa nanaanə pəd̃aw

Gl: ***she that mine this FOC how surprise***

Free: He said 'How can this be?

82

UR: **tam kùlu anɨ kay, cáwa-ŋ wara tà tà àtɨ kàr ana aŋa mɔ**

Phon: ta-m gùlù: nɨ̄kāy (pause) cə́wáŋ wārdà: dàa dɨ̀: gàr 'ānāaŋāa mɔ̀::

Pars: **(tam)(gulu:)(nɨkay)] (cəwaŋ)] (war)(da:)(daa)(dɨ:)(gar)('anaa)(ŋaa)(mɔ:)**

Orth: Tam gulu anəkay, cəwaŋ warda da adə gar anaaŋa mɔ

Gl: ***you look-at-it like-this the-sun over-there to-here in placed how question***

Free: *Look at it, you can see the sun through it!*

83

UR: **cáwa wara tà àtɨ kàr**

Phon: cə́wá: wārdà: àadɨ̀ gàr

Pars: **(cəwa:)(war)(da:)(aa)(dɨgar)**

Orth: Cəwa warda adə gar.››

Gl: ***sun over-there in placed***

Free: The sun comes through it!'

84

UR: **kaya tiikɨ́ ís-ŋ pɨ̀ waat-ɛ a káa kə àpláw-aŋ míntí...**

Phon: kəyā tīikɨ́ ɨsíŋ bɨ̀ wāatə̄ káa kābbɨ̀lwáŋ míntí

Pars: **(kəya)(tii)kɨ] (ɨsɨŋ)(bɨwaa)(təkaa)(kab)(bɨl)(waŋ)(min)ti**

Orth: Kəya tiikə əsəŋ bə waate a kaa kə ablawaŋ minti...

Gl: ***then squirrel started to speak to people of lots that***

Free: *Then Squirrel said to everyone...*

85

UR: **hùlum yaŋ pɨ̀ mɔ́ɔr-ɛ atàwalta-ŋa**

Phon: hùlùm yāŋ bɨ̀ mɔ́ɔré: dəwàldə̄ŋā::

Pars: **(hulum)(yaŋ)(bɨmɔɔ)(rɛ:)(dəwal)(dəŋa:)**

Orth: Hulum yaŋ bə moore adəwaldə ŋaŋa

Gl: ***man exists of grumbling among-us***

Free: *Is there someone grumbling here amongst us?*

86

UR: **kɔ̀rnɔy míntí paapa, ten mɔ́ɔr-ɛ paapa mɔ́ɔr-ɛ pà**

Phon: gɔ̀rnɔ̀y míntí (pause) pāapā (pause) tɛ̄n mɔ́ɔré: pāapə̄ mɔ́ɔré bà::

Pars: **(gɔr)(nɔy)(min)ti] (paa)pa] (ten)(mɔɔ)(rɛ:)(paa)(pəmɔɔ)(reba:)**

Orth: Gornoy minti: ‹‹ Paapa, ten moore paapa moore ba! ››

Gl: ***hyena that no I grumble not grumble not***

Free: *Hyena said 'No, no, no, I'm not really grumbling!'*

87

UR: **tá a waat-ŋ war-a pàkŋ̍**

Phon: tá ā wāatāŋ wərā bàgŋ̍

Pars: **(taa)(waa)(taŋ)(wəra)(bagŋ̍)**

Orth: Tá a waataŋ wəra bagŋ

Gl: ***she had spoken ACC only***

Free: *He (hyena) had said simply this...*

88

UR: **wɨ káy kataŋ, wɨ a wara tà káy haa pá?**

Phon: wɨ̄ káy kə̄tāŋ (pause) wɨ̄ wārdə̀ káy hāa pá::

Pars: **(wɨkay)(kətaŋ)] (wɨwar)(dəkay)(haa)(pa:)**

Orth: ‹‹ Wə kay kətaŋ, wə a warda kay haa pa?

Gl: ***he this thing he at out-there this FOC again***

Free: *'He is like this (untransparent) when with me, and elsewhere too*

89

UR: **sáma-ŋ, tɛn tàw anɨ kay, cáwa-ŋ wara tà tɨ àtɨ kàr**

Phon: sə́máŋ tɛ̄n dàw ānkāy (pause) cə́wáŋ wārdə̀ dàd gàr

Pars: **(səmaŋ)(tɛn)(daw)(ankay)] (cəwaŋ)(war)(dədad)(gar)**

Orth: Səmaŋ, ten daw anəkay, cəwaŋ warda də adə gar.

Gl: ***but I grab-it like-this sun out there in placed***

Free: *But when I hold himup, you can see the sun through him.*

90

UR: **haa náaní mɔ́?**

Phon: hāa náaní mɔ́::

Pars: **(haa)(naa)(nɨmɔ:)**

Orth: Haa naanə mo? ››

Gl: ***FOC what question***

Free: *How can this be?'*

91

UR: **kaŋ fáa hìŋ fad**

Phon: kāŋ fáa hìŋ fādī::

Pars: **(kaŋ)(faa)(hiŋ)(fad)(i:)**

Orth: Kaŋ faa hiŋ fadī.

Gl: ***people got-up laugh immediately***

Free: *The people immediately started to laugh.*

92

UR: Ajùjun hɔ́lɔŋ dɨ̀r-a

Phon: ā: jùn hɔ́lɔ́ŋ dɨ̀rɨ̀::

Pars: (a:)(jun)(holɔŋ)(dɨ̀rɨ:)

Orth: Ajujun holoŋ dərə.

Gl: story well to-her-eyes

Free: The end!

Free translation:

Once upon a time, squirrel was looking for a way to trick hyena. So he gathered together all the animals, including the ants right up to the elephant. He put ropes round the necks of these animals and placed them inside a building. He then took the other end of all the ropes and placed them outside on show. He had put the thick rope round the neck of the bat.

Then he said to the people, 'Look at these ropes! You can choose one and then you will get the animal which is at the other end of the rope – so if you pull out a chicken, that is what you will get, if you pull out an elephant, you will have that to eat all by yourself, but if you have the bad luck to get an ant – that's what you'll eat – because you haven't got the elephant or the hippo!'

He asked them if they understood, then hyena said, 'Relax uncle! You're tired, I'll explain to everyone.' While he was explaining, he put his foot on the thick rope because he thought it must be the elephant or hippo. He said to the people, 'What our uncle said is clear and cannot be misunderstood. You get what is at the end of the rope. If it is a dragonfly, that's what you get. Can you go and demand the elephant or the hippo from the person that has that? No way! That's all I have to say.'

Then squirrel asked him if he had chosen, and squirrel tried to grab the thick rope, but hyena said, 'there are lots of other ropes! Get away, it's mine!' And he pulled on the rope. He thought he would get a hippo or an elephant, but what he got was...a bat! The dragonfly got the elephant and the lizards got the hippo. Someone said, 'Don't grumble!' Hyena grabbed his bat and lifted it up. He said, 'You can see the sun through it! Look!' Squirrel asked, 'Is there someone mumbling here?' Hyena said, 'No, no, no! It is just that this is strange, you can see the sun through it!' The people just laughed.